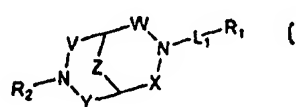
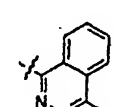
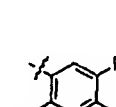
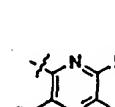
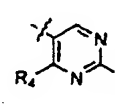
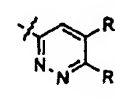
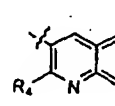
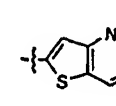
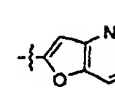
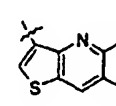
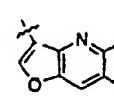
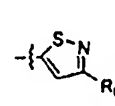
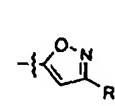




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification <sup>7</sup> :  <b>C07D 487/08, A61K 31/395, A61P 25/00, C07D 471/08, 519/00 // (C07D 487/08, 209:00, 209:00) (C07D 487/08, 241:00, 209:00) (C07D 471/08, 221:00, 209:00) (C07D 487/08, 243:00, 209:00)</b></p>	<b>A1</b>	<p>(11) International Publication Number: <b>WO 00/44755</b></p> <p>(43) International Publication Date: 3 August 2000 (03.08.00)</p>
<p>(21) International Application Number: <b>PCT/US00/01620</b></p> <p>(22) International Filing Date: 25 January 2000 (25.01.00)</p> <p>(30) Priority Data:  09/239,838 29 January 1999 (29.01.99) <b>US</b></p> <p>(71) Applicant: <b>ABBOTT LABORATORIES [US/US]; CHAD 0377/AP6D-2, 100 Abbott Park Road, Abbott Park, IL 60064-6050 (US).</b></p> <p>(72) Inventors: <b>BUNNELLE, William, H.; 1826 Victoria Way, Mundelein, IL 60060 (US). CRISTINA, Daniela, Barlocco; Via G Frua, 20, I-20146 Milano (IT). DAANEN, Jerome, F.; 4137 Nantucket Place, Racine, WI 53405 (US). DART, Michael, J.; 1026 Princeton Avenue, Highland Park, IL 60035 (US). MEYER, Michael, D.; 25151 Amanda Court, Lake Villa, IL 60046 (US). RYTHER, Keith, B.; 862 Water-view Drive, Round Lake Park, IL 60073 (US). SCHRIMPF, Michael, R.; 327 Cambridge Drive, Grayslake, IL 60030 (US). SIPPY, Kevin, B.; 633 Wood Creek Dr., Antioch, IL 60613 (US). TOUPENCE, Richard, B.; 4239 N. Hermitage Avenue, Chicago, IL 60613 (US).</b></p>		<p>(74) Agents: <b>MILLER, Robert, A. et al.; Abbott Laboratories, CHAD 0377/AP6D-2, 100 Abbott Park Road, Abbott Park, IL 60064-6050 (US).</b></p> <p>(81) Designated States: <b>AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</b></p> <p><b>Published</b>  <i>With international search report.</i>  <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>
<p>(54) Title: <b>DIAZABICYCLIC DERIVATIVES AS NICOTINIC ACETYLCHOLINE RECEPTOR LIGANDS</b></p>		
<div style="display: flex; flex-wrap: wrap; justify-content: space-around;"> <div style="text-align: center;">  <p>(I)</p> </div> <div style="text-align: center;">  <p>(a)</p> </div> <div style="text-align: center;">  <p>(b)</p> </div> <div style="text-align: center;">  <p>(c)</p> </div> <div style="text-align: center;">  <p>(d)</p> </div> <div style="text-align: center;">  <p>(e)</p> </div> <div style="text-align: center;">  <p>(f)</p> </div> <div style="text-align: center;">  <p>(g)</p> </div> <div style="text-align: center;">  <p>(h)</p> </div> <div style="text-align: center;">  <p>(i)</p> </div> <div style="text-align: center;">  <p>(j)</p> </div> <div style="text-align: center;">  <p>(k)</p> </div> <div style="text-align: center;">  <p>(l)</p> </div> </div>		
<p>(57) Abstract</p> <p>Compounds of formula (I) or a pharmaceutically acceptable salt thereof wherein: V is selected from the group consisting of a covalent bond and CH<sub>2</sub>; W is selected from the group consisting of a covalent bond, CH<sub>2</sub> and CH<sub>2</sub>CH<sub>2</sub>; X is selected from the group consisting of a covalent bond and CH<sub>2</sub>; Y is selected from the group consisting of a covalent bond, CH<sub>2</sub>, and CH<sub>2</sub>CH<sub>2</sub>; Z is selected from the group consisting of CH<sub>2</sub>, CH<sub>2</sub>CH<sub>2</sub>, and CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>; L<sub>1</sub> is selected from the group consisting of a covalent bond and (CH<sub>2</sub>)<sub>n</sub>; n is 1-5; R<sub>1</sub> is selected from the group consisting of (a), (b), (c), (d), (e), (f), (g), (h), (i), (j), (k), and (l); R<sub>2</sub> is selected from the group consisting of hydrogen, alkoxycarbonyl, alkyl, aminoalkyl, aminocarbonylalkyl, benzyloxycarbonyl, cyanoalkyl, dihydro-3-pyridinylcarbonyl, hydroxy, hydroxyalkyl, phenoxy, and -NH<sub>2</sub>; are useful for controlling synaptic transmission in mammal.</p>		

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## DIAZABICYCLIC DERIVATIVES AS NICOTINIC ACETYLCHOLINE RECEPTOR LIGANDS

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## FIELD OF THE INVENTION

The present invention is directed to a series of N-substituted diazabicyclic compounds, methods for selectively controlling neurotransmitter release in mammals using these compounds, and pharmaceutical compositions containing these compounds.

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## BACKGROUND OF THE INVENTION

Compounds that selectively control chemical synaptic transmission offer therapeutic utility in treating disorders that are associated with dysfunctions in synaptic transmission. This utility may arise from controlling either pre-synaptic or post-synaptic chemical transmission. The control of synaptic chemical transmission is, in turn, a direct result of a modulation of the excitability of the synaptic membrane. Presynaptic control of membrane excitability results from the direct effect an active compound has upon the organelles and enzymes present in the nerve terminal for synthesizing, storing, and releasing the neurotransmitter, as well as the process for active re-uptake. Postsynaptic control of membrane excitability results from the influence an active compound has upon the cytoplasmic organelles that respond to neurotransmitter action.

An explanation of the processes involved in chemical synaptic transmission will help to illustrate more fully the potential applications of the invention. (For a fuller explanation of chemical synaptic transmission refer to Hoffman et al., "Neuro-transmission: The autonomic and somatic motor nervous systems." In: Goodman and Gilman's, The Pharmacological Basis of Therapeutics, 9th ed., J.G. Hardman, L.E. Limbird, P.B. Molinoff, R.W. Ruddon, and A. Goodman Gilman, eds., Pergamon Press, New York, (1996), pp. 105-139).

Typically, chemical synaptic transmission begins with a stimulus that depolarizes the transmembrane potential of the synaptic junction above the threshold that elicits an

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all-or-none action potential in a nerve axon. The action potential propagates to the nerve terminal where ion fluxes activate a mobilization process leading to neurotransmitter secretion and "transmission" to the postsynaptic cell. Those cells which receive communication from the central and peripheral nervous systems in the form of neurotransmitters are referred to as "excitable cells." Excitable cells are cells such as nerves, smooth muscle cells, cardiac cells and glands. The effect of a neurotransmitter upon an excitable cell may be to cause either an excitatory or an inhibitory postsynaptic potential (EPSP or IPSP, respectively) depending upon the nature of the postsynaptic receptor for the particular neurotransmitter and the extent to which other neurotransmitters are present. Whether a particular neurotransmitter causes excitation or inhibition depends principally on the ionic channels that are opened in the postsynaptic membrane (i.e., in the excitable cell).

EPSPs typically result from a local depolarization of the membrane due to a generalized increased permeability to cations (notably  $\text{Na}^+$  and  $\text{K}^+$ ), whereas IPSPs are the result of stabilization or hyperpolarization of the membrane excitability due to a increase in permeability to primarily smaller ions (including  $\text{K}^+$  and  $\text{Cl}^-$ ). For example, the neurotransmitter acetylcholine excites at skeletal muscle junctions by opening permeability channels for  $\text{Na}^+$  and  $\text{K}^+$ . At other synapses, such as cardiac cells, acetylcholine can be inhibitory, primarily resulting from an increase in  $\text{K}^+$  conductance.

The biological effects of the compounds of the present invention result from modulation of a particular subtype of acetylcholine receptor. It is, therefore, important to understand the differences between two receptor subtypes. The two distinct subfamilies of acetylcholine receptors are defined as nicotinic acetylcholine receptors and muscarinic acetylcholine receptors. (See Goodman and Gilman's, The Pharmacological Basis of Therapeutics, op. cit.).

The responses of these receptor subtypes are mediated by two entirely different classes of second messenger systems. When the nicotinic acetylcholine receptor is activated, the response is an increased flux of specific extracellular ions (e.g.  $\text{Na}^+$ ,  $\text{K}^+$  and  $\text{Ca}^{++}$ ) through the neuronal membrane. In contrast, muscarinic acetylcholine receptor activation leads to changes in intracellular systems that contain complex molecules such as G-proteins and inositol phosphates. Thus, the biological consequences of nicotinic



acetylcholine receptor activation are distinct from those of muscarinic receptor activation. In an analogous manner, inhibition of nicotinic acetylcholine receptors results in still other biological effects, which are distinct and different from those arising from muscarinic receptor inhibition

5           As indicated above, the two principal sites to which drug compounds that affect chemical synaptic transmission may be directed are the presynaptic membrane and the post-synaptic membrane. Actions of drugs directed to the presynaptic site may be mediated through presynaptic receptors that respond to the neurotransmitter which the same secreting structure has released (i.e., through an autoreceptor), or through a  
10       presynaptic receptor that responds to another neurotransmitter (i.e., through a heteroreceptor). Actions of drugs directed to the postsynaptic membrane mimic the action of the endogenous neurotransmitter or inhibit the interaction of the endogenous neurotransmitter with a postsynaptic receptor.

          Classic examples of drugs that modulate postsynaptic membrane excitability are  
15       the neuromuscular blocking agents which interact with nicotinic acetylcholine-gated channel receptors on skeletal muscle, for example, competitive (stabilizing) agents, such as curare, or depolarizing agents, such as succinylcholine.

          In the central nervous system, postsynaptic cells can have many neurotransmitters impinging upon them. This makes it difficult to know the precise net balance of  
20       chemical synaptic transmission required to control a given cell. Nonetheless, by designing compounds that selectively affect only one pre- or postsynaptic receptor, it is possible to modulate the net balance of all the other inputs. Obviously, the more that is understood about chemical synaptic transmission in CNS disorders, the easier it would be to design drugs to treat such disorders.

25           Knowing how specific neurotransmitters act in the CNS allows one to predict the disorders that may be treatable with certain CNS-active drugs. For example, dopamine is widely recognized as an important neurotransmitter in the central nervous systems in humans and animals. Many aspects of the pharmacology of dopamine have been reviewed by Roth and Elsworth, "Biochemical Pharmacology of Midbrain Dopamine  
30       Neurons", In: Psychopharmacology: The Fourth Generation of Progress, F.E. Bloom and D.J. Kupfer, Eds., Raven Press, NY, 1995, pp 227-243). Patients with Parkinson's

disease have a primary loss of dopamine containing neurons of the nigrostriatal pathway, which results in profound loss of motor control. Therapeutic strategies to replace the dopamine deficiency with dopamine mimetics, as well as administering pharmacologic agents that modify dopamine release and other neurotransmitters have been found to have therapeutic benefit ("Parkinson's Disease", In: Psychopharmacology: The Fourth Generation of Progress, op. cit., pp 1479-1484).

New and selective neurotransmitter controlling agents are still being sought, in the hope that one or more will be useful in important, but as yet poorly controlled, disease states or behavior models. For example, dementia, such as is seen with Alzheimer's disease or Parkinsonism, remains largely untreatable. Symptoms of chronic alcoholism and nicotine withdrawal involve aspects of the central nervous system, as does the behavioral disorder Attention-Deficit Disorder (ADD). Specific agents for treatment of these and related disorders are few in number or non-existent.

A more complete discussion of the possible utility as CNS-active agents of compounds with activity as cholinergic ligands selective for neuronal nicotinic receptors, (i.e., for controlling chemical synaptic transmission) may be found in U.S. Patent 5,472,958, to Gunn et al., issued Dec. 5, 1995, which is incorporated herein by reference.

Existing acetylcholine agonists are therapeutically suboptimal in treating the conditions discussed above. For example, such compounds have unfavorable pharmacokinetics (e.g., arecoline and nicotine), poor potency and lack of selectivity (e.g., nicotine), poor CNS penetration (e.g., carbachol) or poor oral bioavailability (e.g., nicotine). In addition, other agents have many unwanted central agonist actions, including hypothermia, hypolocomotion and tremor and peripheral side effects, including miosis, lachrymation, defecation and tachycardia (Benowitz et al., in: Nicotine Psychopharmacology, S. Wonnacott, M.A.H. Russell, & I.P. Stolerman, eds., Oxford University Press, Oxford, 1990, pp. 112-157; and M. Davidson, et al., in Current Research in Alzheimer Therapy, E. Giacobini and R. Becker, ed.; Taylor & Francis: New York, 1988; pp 333-336).

Williams et al. reports the use of cholinergic channel modulators to treat Parkinson's and Alzheimer's Diseases. M. Williams et al., "Beyond the Tobacco Debate: Dissecting Out the Therapeutic Potential of Nicotine", Exp. Opin. Invest. Drugs

5, pp. 1035-1045 (1996). Salin-Pascual et al. reports short-term improvement of non-smoking patients suffering from depression by treatment with nicotine patches. R. J. Salin-Pascual et al., "Antidepressant Effect of Transdermal Nicotine Patches in Non-Smoking Patients with Major Depression", J. Clin. Psychiatry, v. 57 pp. 387-389 (1996).

5        Some diazabicyclo[2.2.1]heptane derivatives have been disclosed for various purposes. For example, N-heteroaromatic, N-alkylaryl substituted diazabicyclo[2.2.1]heptanes have been disclosed in European Patent Application No. 0 400 661 for the prevention of disorders resulting from brain and/or spinal cord anoxia; N-heteroaromatic, N-alkylaryl diazabicyclo[2.2.1]heptane derivatives have been  
10        disclosed in European Patent Application 0 324 543 as antiarrhythmic agents; N-heteroaromatic, -alkylaryl diazabicyclo[2.2.1]heptane derivatives have been disclosed in European Patent Publication No. 0 345 808 B1 for the treatment of depression; N-alkylamidoheteroaromatic, N-alkylaromatic diazabicyclo[2.2.1] heptane derivatives have been disclosed in U.S. Patent No. 5,382,584 for effective anti-ischemic protection for  
15        CNS and cardiac tissue, di-N-acylheteroaromatic diazabicyclo[2.2.1] heptane derivatives have been disclosed in PCT Publication No. WO97/17961 to stimulate hematopoiesis and for the treatment of viral, fungal and bacterial infectious diseases. Moreover NH or N-methyl N-heteroaromatic diazabicyclo[2.2.1] heptane derivatives for treating central cholinergic disfunction have been disclosed in U.S. Patent No. 5,478,939. The  
20        heteroaromatic compounds can be halo-substituted pyrazines, thiazoles, thiadiazoles, thiophene or nitrobenzene, as disclosed in U.S. Patent No. 5,478,939.

      Substituted diazabicyclo[3.2.1]octane derivatives have also been disclosed for various uses. For example, NH or N-alkyl, N-2-pyrimidinyl diazabicyclo[3.2.1] octane derivatives for sedatives have been disclosed in French Publication 2 531 709; N-acyl, -  
25        acylheteroaromatic diazabicyclo[3.2.1]octane derivatives have been disclosed in PCT Publication No. WO 95/23152 for central analgesic activity, 3-[6-Cl-pyridazin-3-yl]-diazabicyclo[3.2.1]octane having antinociceptive effect was disclosed in Drug Development Research, 40:251-258 (1997); and NH, N-halosubstituted heteroaromatic diazabicyclo[3.2.1]octane derivatives as analgesics were disclosed in J. Med. Chem, 1998,  
30        41, 674-681. However, there is still a need for even more effective N-substituted diazabicyclic compounds.

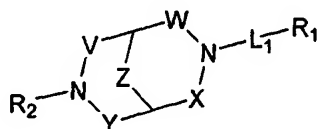
It is therefore an object of this invention to provide novel N-substituted diazabicyclic compounds. It is a further object of this invention to provide such compounds which selectively control neurotransmitter release.

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## SUMMARY OF THE INVENTION

The present invention discloses N-substituted diazabicyclic compounds, a method for selectively controlling neurotransmitter release in mammals using these compounds, and pharmaceutical compositions including those compounds. More particularly, the present invention is directed to compounds of formula I:

10



I,

and their pharmaceutically acceptable salts wherein:

V is selected from the group consisting of a covalent bond and  $\text{CH}_2$ ;

W is selected from the group consisting of a covalent bond,  $\text{CH}_2$ , and  $\text{CH}_2\text{CH}_2$ ;

15

X is selected from the group consisting of a covalent bond and  $\text{CH}_2$ ;

Y is selected from the group consisting of a covalent bond,  $\text{CH}_2$ , and  $\text{CH}_2\text{CH}_2$ ;

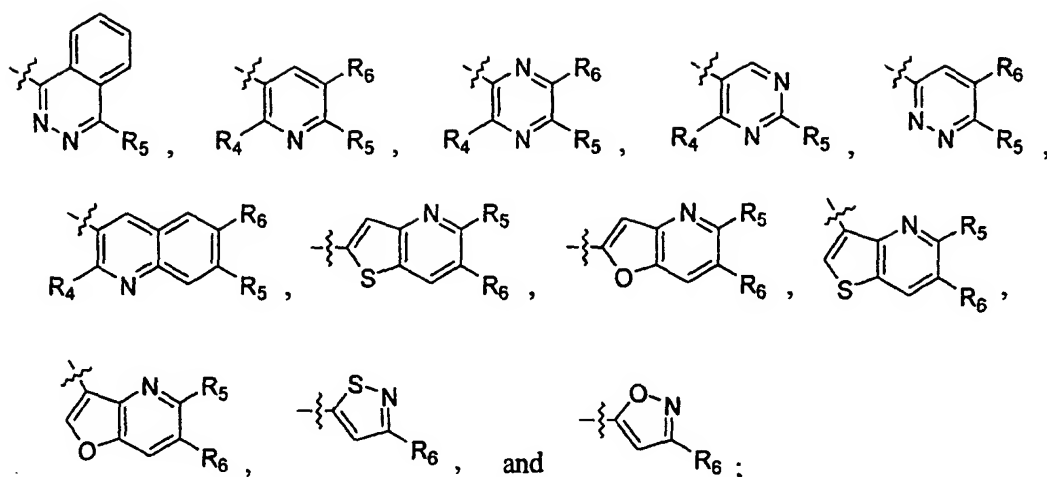
Z is selected from the group consisting of  $\text{CH}_2$ ,  $\text{CH}_2\text{CH}_2$ , and  $\text{CH}_2\text{CH}_2\text{CH}_2$ ;

$\text{L}_1$  is selected from the group consisting of a covalent bond and  $(\text{CH}_2)_n$ ;

n is 1-5;

20

$\text{R}_1$  is selected from the group consisting of



$R_2$  is selected from the group consisting of hydrogen, alkoxycarbonyl, alkyl, aminoalkyl, aminocarbonylalkyl, benzyloxycarbonyl, cyanoalkyl, dihydropyridin-3-ylcarbonyl, hydroxy, hydroxyalkyl, phenoxy, and  $-NH_2$ ;

$R_4$  is selected from the group consisting of hydrogen, alkyl, and halogen;

$R_5$  is selected from the group consisting of hydrogen, alkoxy, alkyl, halogen, nitro, and  $-NH_2$ ;

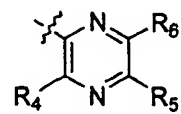
$R_6$  is selected from the group consisting of hydrogen, alkenyl, alkoxy, alkoxyalkoxy, alkoxyalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, alkyl, alkylcarbonyl, alkylcarbonyloxy, alkylthio, alkynyl, amino, aminoalkyl, aminocarbonyl, aminocarbonylalkyl, aminosulfonyl, carboxy, carboxyalkyl, cyano, cyanoalkyl, formyl, formylalkyl, haloalkoxy, haloalkyl, halogen, hydroxy, hydroxyalkyl, mercapto, mercaptoalkyl, nitro, 5-tetrazolyl,  $-NR_7SO_2R_8$ ,  $-C(NR_7)NR_7R_8$ ,  $-CH_2C(NR_7)NR_7R_8$ ,  $-C(NOR_7)R_8$ ,  $-C(NCN)R_7$ ,  $-C(NNR_7R_8)R_8$ ,  $-S(O)_2OR_7$ , and  $-S(O)_2R_7$ ; and

$R_7$  and  $R_8$  are independently selected from the group consisting of hydrogen and alkyl;

with the proviso that the following compounds are excluded,

3-(6-chloro-3-pyridazinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(6-chloro-2-pyrazinyl)-3,8-diazabicyclo[3.2.1]octane;  
 8-(6-chloro-3-pyridazinyl)-3,8-diazabicyclo[3.2.1]octane; and  
 8-(6-chloro-2-pyrazinyl)-3,8-diazabicyclo[3.2.1]octane; and

with the further proviso that when V and X are each a covalent bond; W, Y, and Z are each CH<sub>2</sub>; and L<sub>1</sub> is a covalent bond; then R<sub>1</sub> is other than

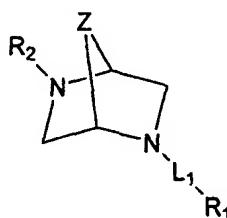


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## DETAILED DESCRIPTION OF THE INVENTION

In one embodiment of the present invention are disclosed compounds of formula

II:



II,

10 and their pharmaceutically acceptable salts wherein Z is selected from CH<sub>2</sub> and CH<sub>2</sub>CH<sub>2</sub>; and L<sub>1</sub>, R<sub>1</sub>, and R<sub>2</sub> are as defined in formula I.

Representative compounds of this embodiment include, but are not limited to:

(1S,4S)-2-(6-chloro-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane;

(1S,4S)-2-(6-chloro-5-methyl-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane;

15 (1S,4S)-2-(6-chloro-3-pyridazinyl)-5-methyl-2,5-diazabicyclo[2.2.1]heptane;

(1S,4S)-2-(6-chloro-5-methyl-3-pyridazinyl)-5-methyl-2,5-diazabicyclo[2.2.1]heptane;

(1S,4S)-2-(4-chloro-1-phthalazinyl)-2,5-diazabicyclo[2.2.1]heptane;

(1S,4S)-2-(4-chloro-1-phthalazinyl)-5-methyl-2,5-diazabicyclo[2.2.1]heptane;

20 (1S,4S)-2-(6-chloro-5-methoxycarbonyl-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane;

(1S,4S)-2-(3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane;

(1S,4S)-2-(5-pyrimidinyl)-2,5-diazabicyclo[2.2.1]heptane;

(1S,4S)-2-(3-quinolinyl)-2,5-diazabicyclo[2.2.1]heptane;

25 (1S,4S)-2-(3-methyl-5-isothiazolyl)-2,5-diazabicyclo[2.2.1]heptane;

(1S,4S)-2-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

- (1S,4S)-2-(6-amino-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-[5-(benzyloxy)-3-pyridinyl]-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-[5-hydroxy-3-pyridinyl]-2,5-diazabicyclo[2.2.1]heptane;  
5 (1S,4S)-2-(6-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-nitro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-bromo-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
10 (1S,4S)-2-(5-aminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-aminocarbonyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-chloro-5-hydroxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

The following additional compounds, representative of formula II, may be  
15 prepared by one skilled in the art using known synthetic chemistry methodology or by  
using synthetic chemistry methodology described in the Schemes and Examples  
contained herein.

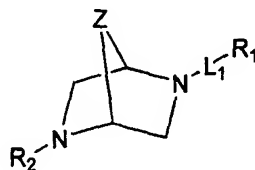
- (1S,4S)-2-(thieno[3,2-b]pyridin-2-yl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(furo[3,2-b]pyridin-2-yl)-2,5-diazabicyclo[2.2.1]heptane;  
20 (1S,4S)-2-(6-chloro-3-pyridinyl)-5-cyanomethyl-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-chloro-5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-chloro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5,6-dichloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
25 (1S,4S)-2-(6-chloro-5-ethynyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-chloro-5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-fluoro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-ethynyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
30 (1S,4S)-2-(5-cyano-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-bromo-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

- (1S,4S)-2-(5-cyano-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-hydroxymethyl-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane; (1S,4S)-2-(5-hydroxymethyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
5 (1S,4S)-2-(5-hydroxymethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-aminomethyl-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-aminomethyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-aminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-carboxy-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
10 (1S,4S)-2-(5-carboxy-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-carboxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-aminocarbonyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-aminocarbonyl-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
15 (1S,4S)-2-(6-chloro-5-hydroxyiminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-fluoro-5-hydroxyiminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
20 (1S,4S)-2-(5-hydroxyiminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(2-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-methyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-aminosulfonyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
25 (1S,4S)-2-(5-aminosulfonyl-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-aminosulfonyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-chloro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
(1S,4S)-2-(5,6-dichloro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
30 (1S,4S)-2-(6-chloro-5-ethynyl-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
(1S,4S)-2-(6-chloro-5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;



- (1S,4S)-2-(5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1S,4S)-2-(6-fluoro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1S,4S)-2-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1S,4S)-2-(5-ethynyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 5 (1S,4S)-2-(5-cyano-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1S,4S)-2-(5-bromo-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1S,4S)-2-(3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane; and  
 (1S,4S)-2-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane.

- 10 In another embodiment of the present invention are disclosed compounds of formula III:



III,

- and their pharmaceutically acceptable salts wherein Z is selected from CH<sub>2</sub> and CH<sub>2</sub>CH<sub>2</sub>;  
 15 and L<sub>1</sub>, R<sub>1</sub>, and R<sub>2</sub> are as defined in formula I.

Representative compounds of this embodiment include, but are not limited to:

- (1R,4R)-2-(6-chloro-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 2-(3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 20 (1R,4R)-2-(5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(thieno[3,2-b]pyridin-2-yl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(6-chloro-3-pyridinyl)-5-cyanomethyl-2,5-diazabicyclo[2.2.1]heptane;  
 25 (1R,4R)-2-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(5-hydroxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(6-chloro-5-hydroxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

- (1R,4R)-2-(6-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(6-chloro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5,6-dichloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-aminocarbonyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
5 (1R,4R)-2-(6-chloro-5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane; and  
(1R,4R)-2-(3-pyridinylmethyl)-2,5-diazabicyclo[2.2.1]heptane.

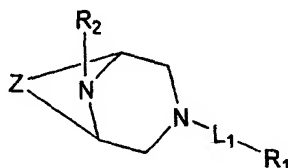
The following additional compounds, representative of formula III, may be prepared by one skilled in the art using known synthetic chemistry methodology or by using synthetic chemistry methodology described in the Schemes and Examples  
10 contained herein.

- (1R,4R)-2-(furo[3,2-b]pyridin-2-yl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(6-chloro-5-methyl-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(6-chloro-3-pyridazinyl)-5-methyl-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(6-chloro-5-methyl-3-pyridazinyl)-5-methyl-2,5-  
15 diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(4-chloro-1-phthalazinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(4-chloro-1-phthalazinyl)-5-methyl-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(6-chloro-5-methoxycarbonyl-3-pyridazinyl)-2,5-  
diazabicyclo[2.2.1]heptane;  
20 (1R,4R)-2-(5-pyrimidinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(3-quinolinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(3-methyl-5-isothiazolyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-bromo-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(6-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
25 (1R,4R)-2-(6-nitro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-bromo-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(6-amino-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-[5-(benzyloxy)-3-pyridinyl]-2,5-diazabicyclo[2.2.1]heptane;  
30 (1R,4R)-2-(6-chloro-5-ethynyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(6-chloro-5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

- (1R,4R)-2-(5-ethynyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-cyano-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-bromo-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-cyano-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
5 (1R,4R)-2-(5-hydroxymethyl-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-hydroxymethyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-hydroxymethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
10 (1R,4R)-2-(5-aminomethyl-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-aminomethyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-aminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-carboxy-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-carboxy-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
15 (1R,4R)-2-(5-carboxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-aminocarbonyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-aminocarbonyl-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
20 (1R,4R)-2-(6-chloro-5-hydroxyiminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(6-fluoro-5-hydroxyiminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-hydroxyiminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
25 (1R,4R)-2-(2-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-methyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-aminosulfonyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-aminosulfonyl-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
30 (1R,4R)-2-(5-aminosulfonyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

- (1R,4R)-2-(6-chloro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1R,4R)-2-(5,6-dichloro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1R,4R)-2-(6-chloro-5-ethynyl-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1R,4R)-2-(6-chloro-5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 5 (1R,4R)-2-(5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1R,4R)-2-(6-fluoro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1R,4R)-2-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1R,4R)-2-(5-ethynyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1R,4R)-2-(5-cyano-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 10 (1R,4R)-2-(5-bromo-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1R,4R)-2-(3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane; and  
 (1R,4R)-2-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane.

In another embodiment of the present invention are disclosed compounds of  
 15 formula IV:



IV,

and their pharmaceutically acceptable salts wherein Z is selected from CH<sub>2</sub>CH<sub>2</sub> and  
 CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>; and L<sub>1</sub>, R<sub>1</sub>, and R<sub>2</sub> are as defined in formula I.

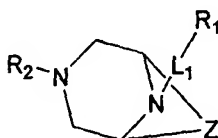
- 20 Representative compounds of this embodiment include, but are not limited to:  
 3-(3-pyridazinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(6-nitro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(6-amino-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(6-chloro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane; and  
 25 3-(3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane.

The following additional compounds, representative of formula IV, may be  
 prepared by one skilled in the art using known synthetic chemistry methodology or by

using synthetic chemistry methodology described in the Schemes and Examples contained herein.

- 3-(6-chloro-5-methyl-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(5,6-dichloro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 5 3-(6-chloro-5-ethynyl-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(6-chloro-5-cyano-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(5-methoxy-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(6-fluoro-5-methyl-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(6-fluoro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 10 3-(5-ethynyl-6-fluoro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(5-cyano-6-fluoro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(5-bromo-6-chloro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(5-aminomethyl-6-chloro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(5-aminomethyl-6-fluoro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane; and  
 15 3-(5-aminomethyl-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane.

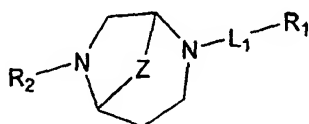
In another embodiment of the present invention are disclosed compounds of formula V:



V,

and their pharmaceutically acceptable salts wherein Z is selected from  $\text{CH}_2\text{CH}_2$  and  $\text{CH}_2\text{CH}_2\text{CH}_2$ ; and  $\text{L}_1$ ,  $\text{R}_1$ , and  $\text{R}_2$  are as defined in formula I.

In another embodiment of the present invention are disclosed compounds of formula VI:



VI,

and their pharmaceutically acceptable salts wherein Z is selected from CH<sub>2</sub> and CH<sub>2</sub>CH<sub>2</sub>; and L<sub>1</sub>, R<sub>1</sub>, and R<sub>2</sub> are as defined in formula I.

A representative compound of this embodiment includes, but is not limited to:

2-(6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane.

5       The following additional compounds, representative of formula VI, may be prepared by one skilled in the art using known synthetic chemistry methodology or by using synthetic chemistry methodology described in the Schemes and Examples contained herein.

2-(3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

10       (1S,5R)-2-(6-chloro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(5,6-dichloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(6-chloro-5-ethynyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(6-chloro-5-cyano-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(5-methoxy-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

15       (1S,5R)-2-(6-fluoro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(5-ethynyl-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(5-cyano-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(5-bromo-6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

20       (1R,5S)-2-(6-chloro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1R,5S)-2-(5,6-dichloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1R,5S)-2-(6-chloro-5-ethynyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1R,5S)-2-(6-chloro-5-cyano-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1R,5S)-2-(5-methoxy-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

25       (1R,5S)-2-(6-fluoro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

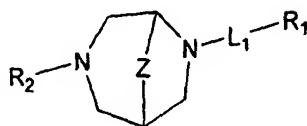
(1R,5S)-2-(6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1R,5S)-2-(5-ethynyl-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1R,5S)-2-(5-cyano-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane; and

(1R,5S)-2-(5-bromo-6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane.

In another embodiment of the present invention are disclosed compounds of formula VII:



VII,

- 5 and their pharmaceutically acceptable salts wherein Z is selected from CH<sub>2</sub> and CH<sub>2</sub>CH<sub>2</sub>; and L<sub>1</sub>, R<sub>1</sub>, and R<sub>2</sub> are as defined in formula I.

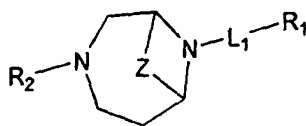
The following compounds, representative of formula VII, may be prepared by one skilled in the art using known synthetic chemistry methodology or by using synthetic chemistry methodology described in the Schemes and Examples contained herein.

- 10 (1R,5R)-6-(6-chloro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-6-(5,6-dichloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-6-(6-chloro-5-ethynyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-6-(6-chloro-5-cyano-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-6-(5-methoxy-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 15 (1R,5R)-6-(6-fluoro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-6-(6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-6-(5-ethynyl-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-6-(5-cyano-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-6-(5-bromo-6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 20 (1R,5R)-6-(3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-6-(6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(6-chloro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(5,6-dichloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(6-chloro-5-ethynyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 25 (1S,5S)-6-(6-chloro-5-cyano-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(5-methoxy-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(6-fluoro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(5-ethynyl-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;

(1S,5S)-6-(5-cyano-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(5-bromo-6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane; and  
 (1S,5S)-6-(6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane.

5

In another embodiment of the present invention are disclosed compounds of formula VIII:



VIII,

10 and their pharmaceutically acceptable salts wherein Z is selected from CH<sub>2</sub>CH<sub>2</sub> and CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>; and L<sub>1</sub>, R<sub>1</sub>, and R<sub>2</sub> are as defined in formula I.

A representative compound of this embodiment includes, but is not limited to:  
 9-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane.

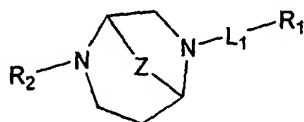
The following additional compounds, representative of formula VIII, may be  
 15 prepared by one skilled in the art using known synthetic chemistry methodology or by using synthetic chemistry methodology described in the Schemes and Examples contained herein.

(1R,6S)-9-(6-chloro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(5,6-dichloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 20 (1R,6S)-9-(6-chloro-5-ethynyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(6-chloro-5-cyano-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(5-methoxy-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(6-fluoro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 25 (1R,6S)-9-(5-ethynyl-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(5-cyano-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(5-bromo-6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;



- (1S,6R)-9-(6-chloro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(5,6-dichloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(6-chloro-5-ethynyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(6-chloro-5-cyano-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 5 (1S,6R)-9-(5-methoxy-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(6-fluoro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(5-ethynyl-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(5-cyano-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 10 (1S,6R)-9-(5-bromo-6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane; and  
 (1S,6R)-9-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane.

- In another embodiment of the present invention are disclosed compounds of  
 15 formula IX:



IX,

- and their pharmaceutically acceptable salts wherein Z is selected from CH<sub>2</sub> and CH<sub>2</sub>CH<sub>2</sub>;  
 and L<sub>1</sub>, R<sub>1</sub>, and R<sub>2</sub> are as defined in formula I.

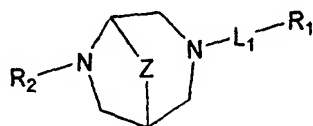
- 20 A representative compound of this embodiment includes, but is not limited to:  
 6-(6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane.

- The following additional compounds, representative of formula IX, may be  
 prepared by one skilled in the art using known synthetic chemistry methodology or by  
 using synthetic chemistry methodology described in the Schemes and Examples  
 25 contained herein.

- (1R,5S)-6-(6-chloro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(5,6-dichloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(6-chloro-5-ethynyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(6-chloro-5-cyano-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

- (1R,5S)-6-(5-methoxy-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(6-fluoro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(5-ethynyl-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 5 (1R,5S)-6-(5-cyano-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(5-bromo-6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(6-chloro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 10 (1S,5R)-6-(5,6-dichloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(6-chloro-5-ethynyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(6-chloro-5-cyano-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(5-methoxy-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(6-fluoro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 15 (1S,5R)-6-(6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(5-ethynyl-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(5-cyano-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(5-bromo-6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane; and  
 20 (1S,5R)-6-(3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane.

In another embodiment of the present invention are disclosed compounds of formula X:



X,

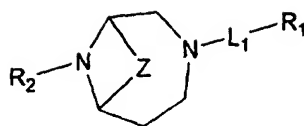
and their pharmaceutically acceptable salts wherein Z is selected from CH<sub>2</sub> and CH<sub>2</sub>CH<sub>2</sub>; and L<sub>1</sub>, R<sub>1</sub>, and R<sub>2</sub> are as defined in formula I.

The following compounds, representative of formula X, may be prepared by one skilled in the art using known synthetic chemistry methodology or by using synthetic chemistry methodology described in the Schemes and Examples contained herein.

- (1R,5R)-3-(6-chloro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
5 (1R,5R)-3-(5,6-dichloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1R,5R)-3-(6-chloro-5-ethynyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1R,5R)-3-(6-chloro-5-cyano-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1R,5R)-3-(5-methoxy-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1R,5R)-3-(6-fluoro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
10 (1R,5R)-3-(6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1R,5R)-3-(5-ethynyl-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1R,5R)-3-(5-cyano-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1R,5R)-3-(5-bromo-6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1R,5R)-3-(6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
15 (1R,5R)-3-(3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1S,5S)-3-(6-chloro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1S,5S)-3-(5,6-dichloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1S,5S)-3-(6-chloro-5-ethynyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1S,5S)-3-(6-chloro-5-cyano-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
20 (1S,5S)-3-(5-methoxy-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1S,5S)-3-(6-fluoro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1S,5S)-3-(6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1S,5S)-3-(5-ethynyl-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1S,5S)-3-(5-cyano-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
25 (1S,5S)-3-(5-bromo-6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
(1S,5S)-3-(6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane; and  
(1S,5S)-3-(3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane.

In another embodiment of the present invention are disclosed compounds of  
30 formula XI:

22



XI,

and their pharmaceutically acceptable salts wherein Z is selected from  $\text{CH}_2\text{CH}_2$  and  $\text{CH}_2\text{CH}_2\text{CH}_2$ ; and  $\text{L}_1$ ,  $\text{R}_1$ , and  $\text{R}_2$  are as defined in formula I.

5 Representative compounds of this embodiment include, but are not limited to:

3-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

9-methyl-3-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane; and

3-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane.

The following additional compounds, representative of formula XI, may be  
 10 prepared by one skilled in the art using known synthetic chemistry methodology or by  
 using synthetic chemistry methodology described in the Schemes and Examples  
 contained herein.

(1R,6S)-3-(6-chloro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

(1R,6S)-3-(5,6-dichloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

15 (1R,6S)-3-(6-chloro-5-ethynyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

(1R,6S)-3-(6-chloro-5-cyano-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

(1R,6S)-3-(5-methoxy-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

(1R,6S)-3-(6-fluoro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

(1R,6S)-3-(6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

20 (1R,6S)-3-(5-ethynyl-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

(1R,6S)-3-(5-cyano-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

(1R,6S)-3-(5-bromo-6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

(1R,6S)-3-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

(1R,6S)-3-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

25 (1S,6R)-3-(6-chloro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

(1S,6R)-3-(5,6-dichloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

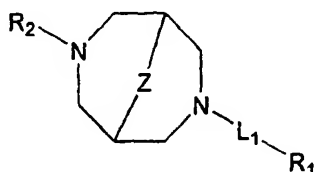
(1S,6R)-3-(6-chloro-5-ethynyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

(1S,6R)-3-(6-chloro-5-cyano-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

(1S,6R)-3-(5-methoxy-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

- (1S,6R)-3-(6-fluoro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-3-(6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-3-(5-ethynyl-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-3-(5-cyano-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 5 (1S,6R)-3-(5-bromo-6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-3-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane; and  
 (1S,6R)-3-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane.

In another embodiment of the present invention are disclosed compounds of  
 10 formula XII:



XII,

and their pharmaceutically acceptable salts wherein Z is selected from CH<sub>2</sub> and  
 CH<sub>2</sub>CH<sub>2</sub>; and L<sub>1</sub>, R<sub>1</sub>, and R<sub>2</sub> are as defined in formula I.

- 15 Representative compounds of this embodiment include, but are not limited to:  
 3-(3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane and  
 3-(6-chloro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane.

The following additional compounds, representative of formula XII, may be  
 prepared by one skilled in the art using known synthetic chemistry methodology or by  
 20 using synthetic chemistry methodology described in the Schemes and Examples  
 contained herein.

- 3-(6-chloro-5-methyl-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;  
 3-(5,6-dichloro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;  
 3-(6-chloro-5-ethynyl-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;  
 25 3-(6-chloro-5-cyano-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;  
 3-(5-methoxy-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;  
 3-(6-fluoro-5-methyl-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;  
 3-(6-fluoro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;

3-(5-ethynyl-6-fluoro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;  
3-(5-cyano-6-fluoro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane; and  
3-(5-bromo-6-chloro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane.

5           Another embodiment of the present invention relates to pharmaceutical compositions comprising a therapeutically effective amount of a compound of formula I or a pharmaceutically acceptable salt thereof in combination with a pharmaceutically acceptable carrier.

          Another embodiment of the present invention relates to a method for selectively  
10       controlling neurotransmitter release in a mammal comprising administering to a mammal in need of such treatment a therapeutically effective amount of a compound of formula I.

          Another embodiment of the present invention relates to a method of treating a disorder, such as Alzheimer's disease, Parkinson's disease, memory dysfunction, Tourette's syndrome, sleep disorders, attention deficit hyperactivity disorder,  
15       neurodegeneration, inflammation, neuroprotection, amyotrophic atal sclerosis, anxiety, depression, mania, schizophrenia, anorexia and other eating disorders, AIDS-induced dementia, epilepsy, urinary incontinence, Crohn's disease, migraines, premenstrual syndrome, erectile dysfunction, substance abuse, smoking cessation, inflammatory bowel syndrome, and pain, in a host mammal in need of such treatment comprising  
20       administering a therapeutically effective amount of a compound of formula I.

#### Definition of Terms

As used throughout this specification and the appended claims, the following terms have the following meanings.

25           The term "alkenyl," as used herein, refers to a straight or branched chain hydrocarbon containing from 2 to 6 carbons and containing at least one carbon-carbon double bond formed by the removal of two hydrogens. Representative examples of alkenyl include, but are not limited to, ethenyl, 2-propenyl, 2-methyl-2-propenyl, 3-butenyl, and 4-pentenyl.

30           The term "alkoxy," as used herein, refers to an alkyl group, as defined herein, appended to the parent molecular moiety through an oxy moiety, as defined herein.

Representative examples of alkoxy include, but are not limited to, methoxy, ethoxy, propoxy, 2-propoxy, butoxy, tert-butoxy, pentyloxy, and hexyloxy.

The term "alkoxyalkoxy," as used herein, refers to an alkoxy group, as defined herein, appended to the parent molecular moiety through another alkoxy group, as defined herein. Representative examples of alkoxyalkoxy include, but are not limited to, tert-butoxymethoxy, 2-ethoxyethoxy, 2-methoxyethoxy, and methoxymethoxy.

The term "alkoxyalkyl," as used herein, refers to an alkoxy group, as defined herein, appended to the parent molecular moiety through an alkyl group, as defined herein. Representative examples of alkoxyalkyl include, but are not limited to, tert-butoxymethyl, 2-ethoxyethyl, 2-methoxyethyl, and methoxymethyl.

The term "alkoxycarbonyl," as used herein, refers to an alkoxy group, as defined herein, appended to the parent molecular moiety through a carbonyl group, as defined herein. Representative examples of alkoxycarbonyl include, but are not limited to, methoxycarbonyl, ethoxycarbonyl, and tert-butoxycarbonyl.

The term "alkoxycarbonylalkyl," as used herein, refers to an alkoxycarbonyl group, as defined herein, appended to the parent molecular moiety through an alkyl group, as defined herein. Representative examples of alkoxycarbonylalkyl include, but are not limited to, 3-methoxycarbonylpropyl, 4-ethoxycarbonylbutyl, and 2-tert-butoxycarbonylethyl.

The term "alkyl," as used herein, refers to a straight or branched chain hydrocarbon containing from 1 to 6 carbon atoms. Representative examples of alkyl include, but are not limited to, methyl, ethyl, n-propyl, iso-propyl, n-butyl, sec-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, and neopentyl.

The term "alkylcarbonyl," as used herein, refers to an alkyl group, as defined herein, appended to the parent molecular moiety through a carbonyl group, as defined herein. Representative examples of alkylcarbonyl include, but are not limited to, acetyl, 1-oxopropyl, 2,2-dimethyl-1-oxopropyl, 1-oxobutyl, and 1-oxopentyl.

The term "alkylcarbonyloxy," as used herein, refers to an alkylcarbonyl group, as defined herein, appended to the parent molecular moiety through an oxy moiety, as defined herein. Representative examples of alkylcarbonyloxy include, but are not limited to, acetyloxy, ethylcarbonyloxy, and tert-butylcarbonyloxy.

The term "alkylthio," as used herein, refers to an alkyl group, as defined herein, appended to the parent molecular moiety through a thio moiety, as defined herein. Representative examples of alkylthio include, but are not limited, methylsulfanyl, ethylsulfanyl, tert-butylsulfanyl, and hexylsulfanyl.

5       The term "alkynyl," as used herein, refers to a straight or branched chain hydrocarbon group containing from 2 to 10 carbon atoms and containing at least one carbon-carbon triple bond. Representative examples of alkynyl include, but are not limited, to acetylenyl, 1-propynyl, 2-propynyl, 3-butyne, 2-pentyne, and 1-butyne.

10       The term "amino," as used herein, refers to  $-NR_{10}R_{11}$ , wherein  $R_{10}$  and  $R_{11}$  are independently selected from hydrogen, alkyl, alkylcarbonyl, and formyl, as defined herein. Representative examples of amino include, but are not limited to, amino, methylamino, ethylmethylamino, methylisopropylamino, dimethylamino, diisopropylamino, diethylamino, formylamino, and acetylethylamino.

15       The term "aminoalkyl," as used herein, refers to an amino group, as defined herein, appended to the parent molecular moiety through an alkyl group, as defined herein. Representative examples of aminoalkyl include, but are not limited to, aminomethyl, 2-aminoethyl, 3-aminopropyl, 4-amino-1-methylhexyl, and 2-(dimethylamino)ethyl.

20       The term "aminocarbonyl," as used herein, refers to an amino group, as defined herein, appended to the parent molecular moiety through a carbonyl group, as defined herein. Representative examples of aminocarbonyl include, but are not limited to, aminocarbonyl, dimethylaminocarbonyl, and ethylmethylaminocarbonyl.

25       The term "aminocarbonylalkyl," as used herein, refers to an aminocarbonyl group, as defined herein, appended to the parent molecular moiety through an alkyl group, as defined herein. Representative examples of aminocarbonylalkyl include, but are not limited to, 2-(aminocarbonyl)ethyl, 3-(dimethylaminocarbonyl)propyl, and ethylmethylaminocarbonylmethyl.

30       The term "aminosulfonyl," as used herein, refers to an amino group, as defined herein, appended to the parent molecular moiety through a sulfonyl group, as defined herein. Representative examples of aminosulfonyl include, but are not limited to, aminosulfonyl, dimethylaminosulfonyl, and ethylmethylaminosulfonyl.



The term "carbonyl," as used herein, refers to a -C(O)- group.

The term "carboxy," as used herein, refers to a -CO<sub>2</sub>H group.

The term "carboxyalkyl," as used herein, refers to a carboxy group, as defined herein, appended to the parent molecular moiety through an alkyl group, as defined  
5 herein. Representative examples of carboxyalkyl include, but are not limited to, carboxymethyl, 2-carboxyethyl, and 3-carboxypropyl.

The term "cyano," as used herein, refers to a -CN group.

The term "cyanoalkyl," as used herein, refers to a cyano group, as defined herein, appended to the parent molecular moiety through an alkyl group, as defined herein.  
10 Representative examples of cyanoalkyl include, but are not limited to, cyanomethyl, 2-cyanoethyl, and 3-cyanopropyl.

The term "formyl," as used herein, refers to a -C(O)H group.

The term "formylalkyl," as used herein, refers to a formyl group, as defined herein, appended to the parent molecular moiety through an alkyl group, as defined  
15 herein. Representative examples of formylalkyl include, but are not limited to, formylmethyl and 2-formylethyl.

The term "halo" or "halogen," as used herein, refers to -Cl, -Br, -I or -F.

The term "haloalkoxy," as used herein, refers to at least one halogen, as defined herein, appended to the parent molecular moiety through an alkoxy group, as defined  
20 herein. Representative examples of haloalkoxy include, but are not limited to, chloromethoxy, 2-fluoroethoxy, trifluoromethoxy, and pentafluoroethoxy.

The term "haloalkyl," as used herein, refers to at least one halogen, as defined herein, appended to the parent molecular moiety through an alkyl group, as defined herein. Representative examples of haloalkyl include, but are not limited to,  
25 chloromethyl, 2-fluoroethyl, trifluoromethyl, pentafluoroethyl, and 2-chloro-3-fluoropentyl.

The term "hydroxy," as used herein, refers to an -OH group.

The term "hydroxyalkyl," as used herein, refers to a hydroxy group, as defined herein, appended to the parent molecular moiety through an alkyl group, as defined  
30 herein. Representative examples of hydroxyalkyl include, but are not limited to, hydroxymethyl, 2-hydroxyethyl, and 3-hydroxypropyl.

The term "mercapto," as used herein, refers to a -SH group.

The term "mercaptoalkyl," as used herein, refers to a mercapto group, as defined herein, appended to the parent molecular moiety through an alkyl group, as defined herein. Representative examples of mercaptoalkyl include, but are not limited to, 2-mercaptoethyl and 3-mercaptopropyl.

The term "N-protecting group" or "nitrogen-protecting group," as used herein, refers to those groups intended to protect an amino group against undesirable reactions during synthetic procedures. N-protecting groups comprise carbamates, amides, alkyl derivatives, amino acetal derivatives, N-benzyl derivatives, imine derivatives, enamine derivatives, and N-heteroatom derivatives. Preferred N-protecting groups are formyl, acetyl, benzoyl, pivaloyl, phenylsulfonyl, benzyl, triphenylmethyl (trityl), t-butyloxycarbonyl (Boc), benzyloxycarbonyl (Cbz). Commonly used N-protecting groups are disclosed in T.H. Greene and P.G.M. Wuts, *Protective Groups in Organic Synthesis*, 2nd edition, John Wiley & Sons, New York (1991).

The term "nitro," as used herein, refers to a -NO<sub>2</sub> group.

The term "oxy," as used herein, refers to a -O- moiety.

The term "sulfonyl," as used herein, refers to a -SO<sub>2</sub>- group.

The term "thio," as used herein, refers to a -S- moiety.

Compounds of the present invention can exist as stereoisomers, wherein asymmetric or chiral centers are present. Stereoisomers are designated "R" or "S," depending on the configuration of substituents around the chiral carbon atom. The terms "R" and "S" used herein are configurations as defined in IUPAC 1974 Recommendations for Section E, Fundamental Stereochemistry, Pure Appl. Chem., (1976), 45: 13-30. In particular, the stereochemistry at the two bridgehead carbon atoms, shown in Formula (I), may independently be either (R) or (S), unless specifically noted otherwise. The present invention contemplates various stereoisomers and mixtures thereof and are specifically included within the scope of this invention. Stereoisomers include enantiomers, diastereomers, and mixtures of enantiomers or diastereomers. Individual stereoisomers of compounds of the present invention may be prepared synthetically from commercially available starting materials which contain asymmetric or chiral centers or by preparation of racemic mixtures followed by resolution well-known to those of

ordinary skill in the art. These methods of resolution are exemplified by (1) attachment of a mixture of enantiomers to a chiral auxiliary, separation of the resulting mixture of diastereomers by recrystallization or chromatography and liberation of the optically pure product from the auxiliary or (2) direct separation of the mixture of optical enantiomers on chiral chromatographic columns.

The compounds of the present invention can be used in the form of pharmaceutically acceptable salts derived from inorganic or organic acids. The phrase "pharmaceutically acceptable salt" means those salts which are, within the scope of sound medical judgement, suitable for use in contact with the tissues of humans and lower animals without undue toxicity, irritation, allergic response and the like and are commensurate with a reasonable benefit/risk ratio.

Pharmaceutically acceptable salts are well-known in the art. For example, S. M. Berge et al. describe pharmaceutically acceptable salts in detail in J. Pharmaceutical Sciences, 1977, 66: 1 et seq. The salts can be prepared in situ during the final isolation and purification of the compounds of the invention or separately by reacting a free base function with a suitable organic acid. Representative acid addition salts include, but are not limited to acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxyethansulfonate (isothionate), lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmitoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, phosphate, glutamate, bicarbonate, p-toluenesulfonate and undecanoate. Also, the basic nitrogen-containing groups can be quaternized with such agents as lower alkyl halides such as methyl, ethyl, propyl, and butyl chlorides, bromides and iodides; dialkyl sulfates like dimethyl, diethyl, dibutyl and diamyl sulfates; long chain halides such as decyl, lauryl, myristyl and stearyl chlorides, bromides and iodides; arylalkyl halides like benzyl and phenethyl bromides and others. Water or oil-soluble or dispersible products are thereby obtained. Examples of acids which can be employed to form pharmaceutically acceptable acid addition salts include such inorganic acids as hydrochloric acid, hydrobromic acid, sulfuric acid, and phosphoric acid and such organic acids as acetic

acid, fumaric acid, maleic acid, 4-methylbenzenesulfonic acid, succinic acid and citric acid.

Basic addition salts can be prepared in situ during the final isolation and purification of compounds of this invention by reacting a carboxylic acid-containing moiety with a suitable base such as the hydroxide, carbonate or bicarbonate of a pharmaceutically acceptable metal cation or with ammonia or an organic primary, secondary or tertiary amine. Pharmaceutically acceptable salts include, but are not limited to, cations based on alkali metals or alkaline earth metals such as lithium, sodium, potassium, calcium, magnesium and aluminum salts and the like and nontoxic quaternary ammonia and amine cations including ammonium, tetramethylammonium, tetraethylammonium, methylamine, dimethylamine, trimethylamine, triethylamine, diethylamine, ethylamine and the like. Other representative organic amines useful for the formation of base addition salts include ethylenediamine, ethanolamine, diethanolamine, piperidine, piperazine and the like.

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#### Abbreviations

Abbreviations which have been used in the descriptions of the schemes and the examples that follow are: Ac for acetyl; AcOH for acetic acid; BINAP for 2,2'-bis(diphenylphosphino)-1,1'-binaphthyl; Boc for tert-butoxycarbonyl; (Boc)<sub>2</sub>O for di-tert-butyl dicarbonate; dba for dibenzylideneacetone; DMF for N,N-dimethylformamide; dppf for 1,1'-bis(diphenylphosphino)ferrocene; EtOAc for ethyl acetate; Et<sub>2</sub>O for diethyl ether; EtOH for ethanol; eq for equivalents; formalin for a solution of formaldehyde (37% by weight) in water; HPLC for high pressure liquid chromatography; LAH for lithium aluminum hydride; MeOH for methanol; Tf for SO<sub>2</sub>CF<sub>3</sub>; TFA for trifluoroacetic acid; THF for tetrahydrofuran; TMS for trimethylsilyl; and TsOH for para-toluenesulfonic acid monohydrate.

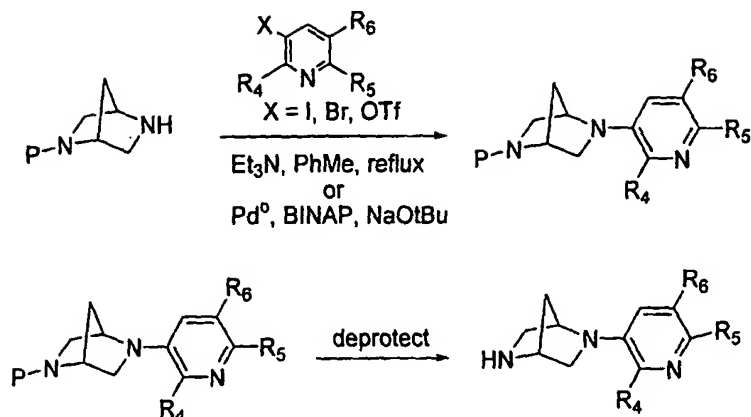
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#### Preparation of Compounds of the Present Invention

The compounds and processes of the present invention will be better understood in connection with the following synthetic Schemes and methods which illustrate a means by which the compounds of the present invention can be prepared.

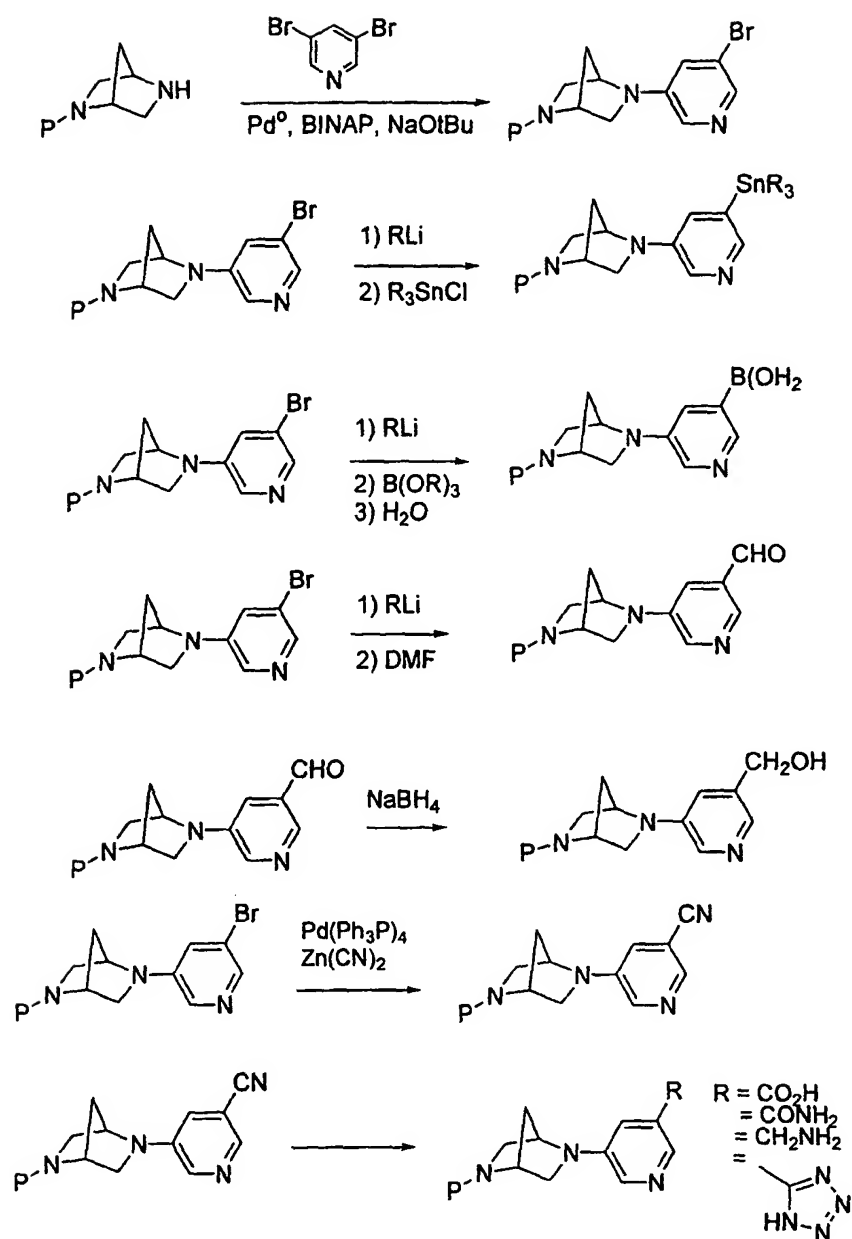
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Scheme 1



The compounds of the present invention can be prepared according to the general approach outlined in Scheme 1. Suitably protected bicyclic diamines, as shown in Scheme 1 wherein P is a nitrogen-protecting group such as alkyl, benzyl, or Boc, can be coupled with a halogenated heterocycle, wherein R<sub>4</sub>, R<sub>5</sub>, and R<sub>6</sub> are as defined in formula I, in the presence of an amine base. Alternatively, less-reactive heterocycles can be coupled using the procedures described in (Wagaw, S. and Buchwald, S. L., J. Org. Chem. 1996, 61, 7240-7241; Bryant, H.Y. and Buchwald, S.L., Journal of Organometallic Chemistry (1999) 576, 125-146). Deprotection under standard conditions affords the desired compounds. Diazabicycloheptanes may be prepared as generally taught and described in Examples 1, 2, 15, and 16. Diazabicyclooctanes may be prepared as generally taught and described in Examples 10, 35, 42, 49, 59, and 60. Diazabicyclononanes may be prepared as generally taught and described in Examples 36, 56, and 57. One skilled in the art would understand that the preparation of larger diazabicyclo compounds, for example decanes, etc., may be prepared synthetically by the Schemes and Examples contained herein as well as general synthetic methodology.

Scheme 2

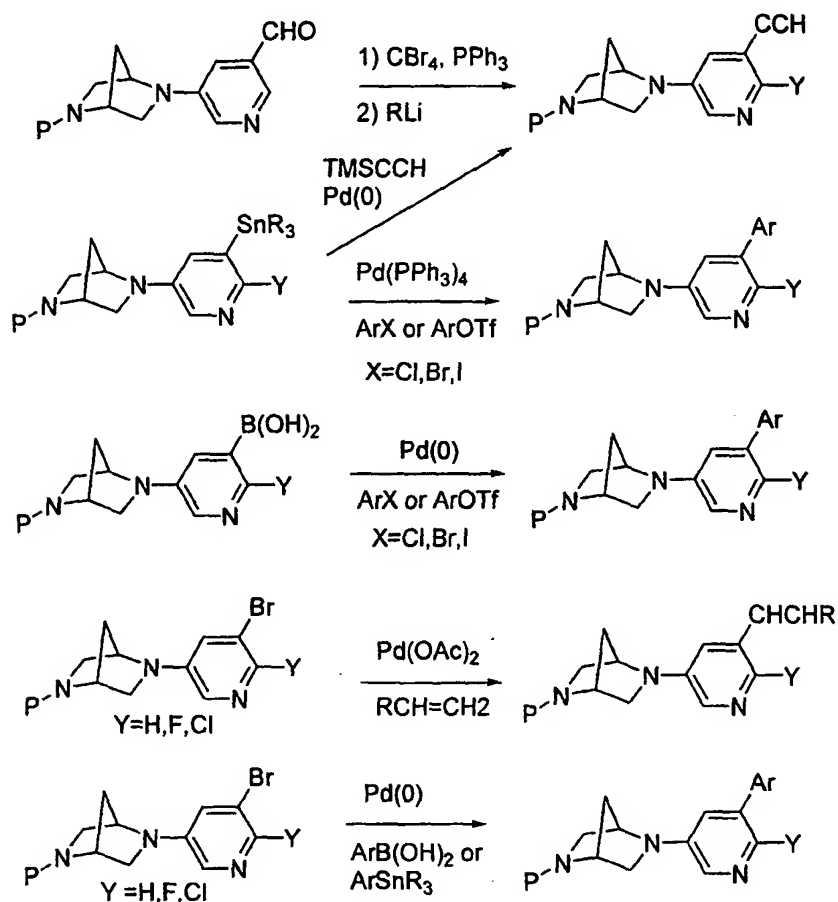


The transformations outlined in Scheme 2 provide compounds which can in turn be elaborated to provide other 5-substituted pyridines. For example, complete or partial hydrolysis of the nitrile leads to the carboxylic acid and amide, respectively. Reduction of the nitrile affords the amine, while cyclization with  $\text{TMSN}_3$  in the presence of  $\text{Bu}_2\text{O}$  as described in (Wittenberger and Donner, J. Org. Chem. 1993 58, 4139) provides the tetrazolyl derivative. The aldehyde can be converted to oximes and hydrazones or

subjected to reductive amination conditions to provide a variety of substituted aminomethyl compounds. Grignard reactions on the aldehyde provides a route to a variety of substituted hydroxymethyl analogs.

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Scheme 3

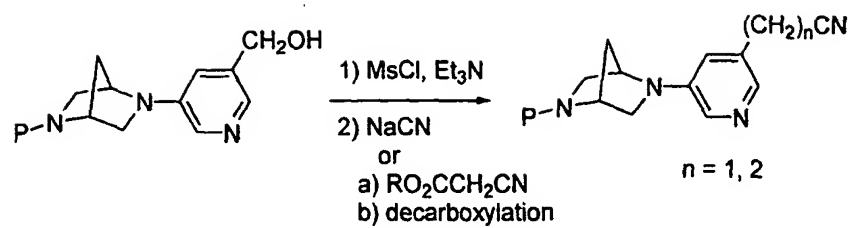


Aldehydes, as shown in Scheme 3, can be elaborated to terminal alkynes using the procedure described in (Tetrahedron Lett. (1972), 3769-3772). Additional elaborations are possible from the tin and boronic acid derivatives, from Scheme 2,

10 which can be coupled with a variety of aryl and vinyl halides and sulfonate esters using transition metal catalysis (e.g., Stille and Suzuki couplings). The 5-bromo derivatives can be engaged in a variety of Pd-catalyzed couplings with alkenes and alkynes (Heck couplings), aryl and vinylstannanes and boronic acids (Stille and Suzuki couplings), as well as alkoxycarbonylations.

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Scheme 4

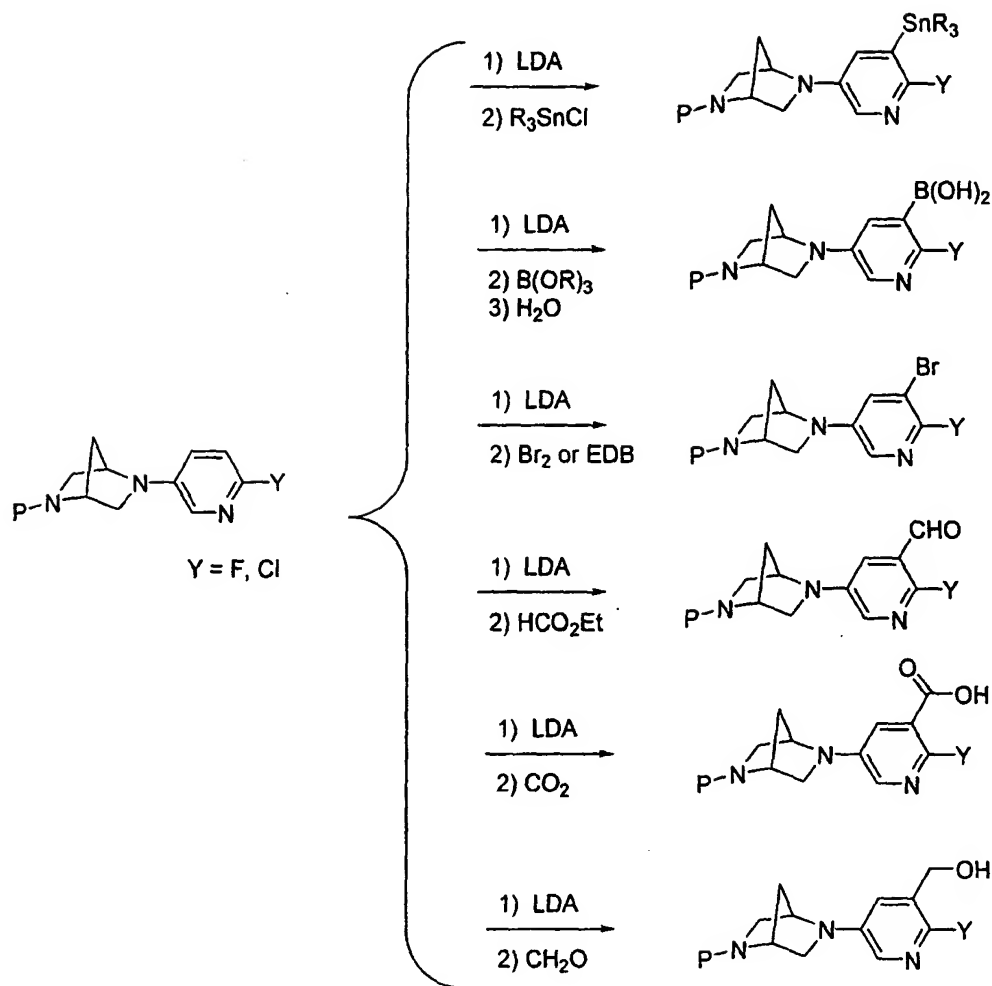


Chain extensions (CN displacement, malonic ester synthesis) can be carried out as described in Scheme 4 to provide the range of substitution patterns encompassed in

5 the claims.



Scheme 5

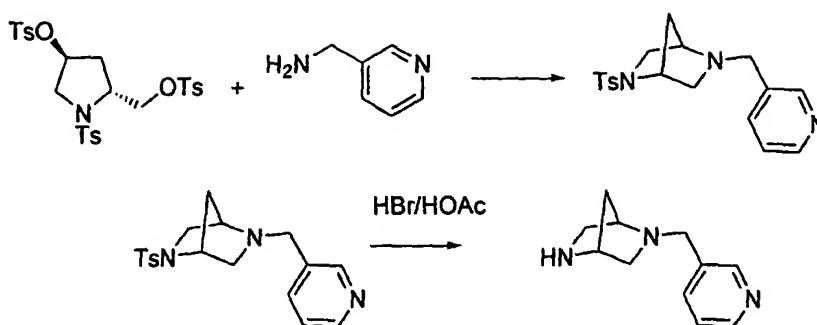


In the cases where the 6-position of the heterocycle is substituted with halogen, an alternate method for functionalizing the 5-position involves ortho-directed metalation according to (Gribble et al., Tetrahedron Lett. (1980) 21, 4137). The metalated species

5 intermediates which can be further elaborated as described in Schemes 3 and 4.

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Scheme 6



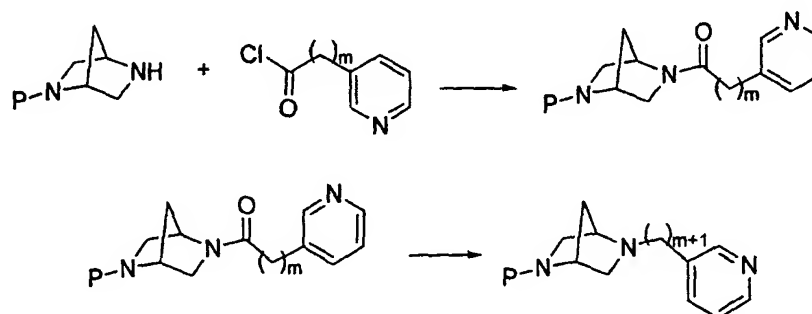
Compounds with 1-5 methylenes between the aromatic heterocycle and the diazabicyclic ring system can be prepared according to the procedure described in

5 Scheme 6. Aminoalkyl heterocycles, prepared using standard synthetic chemistry methodology or purchased commercially, can be condensed with monocyclic precursors to provide N-substituted diazabicyclic systems. For example, (3S,5R)-1-[(4-methylphenyl)sulfonyl]-3-[(4-methylphenyl)sulfonyloxy]-5-[(4-methylphenyl)sulfonyloxymethyl]pyrrolidine prepared as described in (J. Med. Chem.,

10 (1990) 33, 1344), can be condensed with an aminoalkylheterocycle to provide an N-substituted[2.2.1]diazabicyclic system which upon removal of the protecting group, for example with HBr/HOAc, provides the desired compounds. Other spacer lengths are possible by straightforward variation of the starting aminoalkyl heterocycle.

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Scheme 7



Scheme 7 describes an alternate method of preparing compounds with 1-5 methylenes between the aromatic heterocycle and the diazabicyclic ring system. Mono-protected diazabicyclic systems can be acylated with appropriate heterocyclic acid

20 chlorides or anhydrides followed by reduction of the resultant amides using standard

methods available to one skilled in the art provides the desired chain extended compounds.

The following examples are presented to describe preferred embodiments and utilities of the invention and are not meant to limit the invention unless otherwise stated

5 in the claims appended hereto.

Example 1

(1S,4S)-2-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

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Example 1A

tert-butyl (1S,4S)-5-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

In a dry, nitrogen-purged flask, tert-butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate (330 mg, 1.6 mmol), prepared as described in (J. Med. Chem., (1988) 31, 1598-1611), in anhydrous toluene (6 mL) was treated with 2-chloro-5-iodopyridine (383  
15 mg, 1.6 mmol), available as described in (Tetrahedron Lett., (1993), 34, 7493-7496), Pd<sub>2</sub>(dba)<sub>3</sub> (156 mg, 0.16 mmol), BINAP (212 mg, 0.34 mmol), and sodium tert-butoxide (230 mg, 2.4 mmol). The mixture was heated at 70 °C for 24 hours. The reaction mixture was poured into diethyl ether (10 mL) and washed successively with 1N HCl, saturated NaHCO<sub>3</sub>, and brine. The organic phase was dried (MgSO<sub>4</sub>) and concentrated  
20 under reduced pressure. The residue was purified on SiO<sub>2</sub>, eluting with ethyl acetate:hexanes (1:1) to provide the title compound (300 mg, 58% yield) as a light brown solid. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 1.41(s, 4.5H), 1.46(s, 4.5H), 1.93-2.05(m, 2H), 3.14 (d, J=14.7 Hz, 0.5H), 3.35(d, J=14.7 Hz, 0.5H), 3.42(m, 2H), 3.57 (d, 8.45 Hz, 1H),  
25 4.37(s, 1H), 4.53(s, 0.5H), 4.65(s, 0.5H), 6.82(dd, J=2.94, 8.83 Hz, 1H), 7.13(d, J=8.46 Hz, 1H), 7.71(s, 1H); MS (DCI/NH<sub>3</sub>) m/z 310 (M+H)<sup>+</sup>.

Example 1B

(1S,4S)-2-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

30

The product from Example 1A, tert-butyl (1S,4S)-5-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate (386 mg, 1.25 mmol), was charged to a dry, nitrogen-purged flask, and anhydrous ethanol (12 mL) was added. The solution was cooled to 0 °C and treated with 4N HCl/dioxane (1.3 mL). The mixture was allowed to warm to ambient temperature over 0.5 hours, the solvent was removed under reduced pressure, and the residue purified on SiO<sub>2</sub>, eluting with 10% MeOH/CH<sub>2</sub>Cl<sub>2</sub>/1% NH<sub>4</sub>OH to afford the title compound (202 mg, 77% yield) as the free base. The free base was combined with p-toluenesulfonic acid (1 eq) and recrystallized from ethanol/ethyl acetate to provide the title compound. <sup>1</sup>H NMR(free base, CDCl<sub>3</sub>, 300 MHz) δ 1.91-2.13 (AB quartet, J=17.6, 40.7 Hz, 2H), 3.03 (d, J=11.3Hz, 1H), 3.19 (s, 2H), 3.63 (dd, J=2.0, 11.3 Hz, 1H), 3.89 (s, 1H), 4.30 (s, 1H), 6.80 (dd, J=3.4, 8.9 Hz, 1H), 7.20 (d, J=8.8 Hz, 1H), 7.72 (d, J=3.3 Hz, 1H); MS(DCI/NH<sub>3</sub>) m/z 210 (M+H)<sup>+</sup>, 227 (M+NH<sub>4</sub>)<sup>+</sup>; Anal. calculated for C<sub>10</sub>H<sub>12</sub>N<sub>3</sub>Cl•1.25 TsOH C,52.92; H,5.21; N, 9.69. Found C,52.92; H, 5.35; N, 9.64.

### Example 2

(1S,4S)-2-(6-chloro-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane  
bis(4-methylbenzenesulfonate)

### Example 2A

tert-butyl (1S,4S)-5-(6-chloro-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane-2-  
carboxylate

tert-Butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate (342 mg, 1.7 mmol), prepared as described in (J. Med. Chem., (1988) 31, 1598-1611), in anhydrous toluene (8.5 mL) was treated with 3,6-dichloropyridazine (256 mg, 1.7 mmol, Aldrich Chemical Company) and triethylamine (0.24 mL, 170 mg, 1.7 mmol). The reaction mixture was heated to reflux for 16 hours, concentrated under reduced pressure, and the residue purified on SiO<sub>2</sub> (5%MeOH/CH<sub>2</sub>Cl<sub>2</sub>/1%NH<sub>4</sub>OH) to provide the title compound (432 mg, 81% yield) as a white solid. <sup>1</sup>H NMR(CDCl<sub>3</sub>, 300 MHz) δ 1.42(s, 4.5H), 1.46(s, 4.5H), 1.91-2.05(m, 2H), 3.36-3.46 (m, 3H), 3.54-3.60 (m, 1H), 4.57(s, 0.5H),

4.70(s, 0.5H), 4.92(s, 0.5H), 5.07(s, 0.5H), 6.59(d, J=9.20 Hz, 1H), 7.34(d, J=9.56 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 311 (M+H)<sup>+</sup>, 328 (M+NH<sub>4</sub>)<sup>+</sup>.

### Example 2B

5 (1S,4S)-2-(6-chloro-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane  
bis(4-methylbenzenesulfonate)

The product from Example 2A (432 mg, 1.4 mmol) in EtOH (14 mL) at 0 °C was treated with 4M HCl/dioxane (1.4 mL). The reaction was allowed to warm to ambient temperature, concentrated under reduced pressure, and the residue was purified on SiO<sub>2</sub> (10%MeOH/CH<sub>2</sub>Cl<sub>2</sub>/1%NH<sub>4</sub>OH) to provide the free base (231 mg, 79% yield). The free base was treated with p-toluenesulfonic acid (3 eq), and the resultant salt was recrystallized from ethanol/ethyl acetate. <sup>1</sup>H NMR(free base, CDCl<sub>3</sub>, 300 MHz) δ 2.23 (d, J=11.77 Hz, 1H), 2.38(d, J=11.77 Hz, 1H), 3.54(AB quartet, J=11.77, 24.27 Hz, 2H), 3.90(m, 2H), 4.72(s, 1H), 5.21(s, 1H), 7.72(d, J=9.56 Hz, 1H), 7.87(d, J=9.92 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 211 (M+H)<sup>+</sup>, 228 (M+NH<sub>4</sub>)<sup>+</sup>; Anal. calculated for C<sub>9</sub>H<sub>11</sub>N<sub>4</sub>Cl•2.65 TsOH•1.05 H<sub>2</sub>O, C, 48.24; H, 5.04; N, 8.17. Found C, 48.29; H, 5.38; N, 8.18.

### Example 3

20 (1S,4S)-2-(6-amino-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
trihydrochloride

### Example 3A

tert-butyl (1S,4S)-5-(6-nitro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

5-Bromo-2-nitropyridine, prepared as described in (J. Am. Chem. Soc., (1945) 67, 668), and tert-butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate, prepared as described in (J. Med. Chem., (1988) 31, 1598-1611), were coupled according to the procedure of Example 2A to provide the title compound.

### Example 3B

30 (1S,4S)-2-(6-amino-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
trihydrochloride

The product from Example 3A in methanol:ethanol (1:1) was treated with 10% Pd/C under a hydrogen atmosphere (1 atm) for 14 hours. The mixture was filtered, concentrated, and the residue treated with HCl/ether to provide the title compound (65% yield). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>, 300 MHz) δ 2.00 (m, 2H), 3.00 (br s, 2H), 3.4-3.5 (m, 2H),  
5 4.40 (s, 1H), 4.60 (s, 1H), 7.00 (d, J=6.3 Hz, 1H), 7.30 (s, 1H), 7.50 (br s, 2H, exchangeable), 7.70 (d, J=6.3 Hz, 1H), 9.40 (br s, 1H, exchangeable), 9.80 (br s, 2H, exchangeable), 13.0 (br s, 1H, exchangeable).

#### Example 4

10 (1S,4S)-2-(6-chloro-5-methyl-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane  
bis(4-methylbenzenesulfonate)

#### Example 4A

tert-butyl (1S,4S)-5-(6-chloro-5-methyl-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane-2-  
15 carboxylate

3,6-Dichloro-4-methylpyridazine (Aldrich Chemical Company) and tert-butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate, prepared as described in (J. Med. Chem., (1988) 31, 1598-1611), were processed as described in Example 2A to provide the title compound (56% yield). <sup>1</sup>H NMR(CDCl<sub>3</sub>, 300 MHz) δ 1.41 (s, 4.5H), 1.43 (s,  
20 4.5H), 1.90-2.09 (m, 2H), 2.31(s, 3H), 3.35-3.45 (m, 3H), 3.53-3.60(m, 1H), 4.56(s, 0.5H), 4.69(s, 0.5H), 4.90(s, 0.5H), 5.08(s, 0.5H), 6.48(s, 1H); MS (DCI/NH<sub>3</sub>) m/z 325 (M+H)<sup>+</sup>.

#### Example 4B

25 (1S,4S)-2-(6-chloro-5-methyl-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane  
bis(4-methylbenzenesulfonate)

The product of Example 4A was processed as described in Example 2B to provide the title compound (81% yield). <sup>1</sup>H NMR(CDCl<sub>3</sub>, 300 MHz) δ 1.84 (d, J=10.29 Hz, 1H), 1.96 (d, J=9.93 Hz, 1H), 2.32 (s, 3H), 2.92-3.02 (m, 2H), 3.36 (s, 1H), 3.58 (dd,  
30 J=2.21, 9.56 Hz, 1H), 3.83 (s, 1H), 4.76-4.88 (m, 1H), 6.94 (s, 1H); MS (DCI/NH<sub>3</sub>) m/z

225 (M+H)<sup>+</sup>, 242 (M+NH<sub>4</sub>)<sup>+</sup>; Anal. calculated for C<sub>10</sub>H<sub>13</sub>N<sub>4</sub>Cl•2.0 TsOH C, 50.63; H, 5.13; N-9.70. Found C, 50.32; H, 5.15; N, 9.82.

#### Example 5

5      (1S,4S)-2-(6-chloro-3-pyridazinyl)-5-methyl-2,5-diazabicyclo[2.2.1]heptane  
         4-methylbenzenesulfonate

The product from Example 2B (1.0 eq) in formalin (0.1 M) was treated with NaCNBH<sub>3</sub> (1.2 eq) at 0 °C. The reaction was allowed to warm to ambient temperature and stirred for 12 hours. The reaction mixture was quenched with saturated aqueous K<sub>2</sub>CO<sub>3</sub>, extracted with CH<sub>2</sub>Cl<sub>2</sub>, dried (MgSO<sub>4</sub>), and concentrated under reduced pressure. The residue was purified on SiO<sub>2</sub> (10%MeOH/CH<sub>2</sub>Cl<sub>2</sub>/1%NH<sub>4</sub>OH) to provide the free base as a colorless oil (87% yield). The free base was treated with p-toluenesulfonic acid (1.5 eq) and the resultant salt was recrystallized from ethanol/ethyl acetate to provide the title compound. <sup>1</sup>H NMR(free base, CD<sub>3</sub>OD, 300 MHz) δ 2.33 (d, J=10.30 Hz, 1H), 2.48 (s, 3H), 2.50 (d, J=11.77 Hz, 1H), 2.98-3.01 (m, 1H), 3.71-3.87 (m, 3H), 4.49 (s, 1H), 5.06 (s, 1H), 7.54 (d, J=10.26 Hz, 1H), 7.78 (d, J=8.09 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 225 (M+H)<sup>+</sup>, 242 (M+NH<sub>4</sub>)<sup>+</sup>; Anal. calculated for C<sub>10</sub>H<sub>13</sub>N<sub>4</sub>Cl•0.95 TsOH•0.60 H<sub>2</sub>O: C, 50.11; H, 5.51; N, 14.04. Found C, 50.21; H, 5.76; N, 13.98.

#### Example 6

20      (1S,4S)-2-(6-chloro-5-methyl-3-pyridazinyl)-5-methyl-2,5-diazabicyclo[2.2.1]heptane  
         bis(4-methylbenzenesulfonate)

The product from Example 4B was processed as described in Example 5 to provide the title compound (39% yield). <sup>1</sup>H NMR (CD<sub>3</sub>OD, 300 MHz) δ 1.89 (d, J=9.93 Hz, 1H), 2.05 (d, J=9.93 Hz, 1H), 2.29 (s, 3H), 2.45 (s, 3H), 2.76 (d, J=9.56 Hz, 1H), 2.97 (dd, J=1.83, 5.14 Hz, 1H), 3.39 (dd, J=2.21, 9.56 Hz, 1H), 3.58-3.68 (m, 2H), 4.80 (br s, 1H), 6.48 (s, 1H); MS (DCI/NH<sub>3</sub>) m/z 239 (M+H)<sup>+</sup>, 256 (M+NH<sub>4</sub>)<sup>+</sup>; Anal. calculated for C<sub>11</sub>H<sub>15</sub>N<sub>4</sub>Cl•2.2 TsOH•1.80 H<sub>2</sub>O: C, 48.65; H, 5.62; N, 8.48. Found C, 48.61; H, 5.50; N, 8.53.

#### Example 7

(1S,4S)-2-(4-chloro-1-phthalazinyl)-2,5-diazabicyclo[2.2.1]heptane  
bis(4-methylbenzenesulfonate)

Example 7A

5     tert-butyl (1S,4S)-5-(4-chloro-1-phthalazinyl)-2,5-diazabicyclo[2.2.1]heptane-2-  
          carboxylate

1,4-Dichlorophthalazine (Aldrich Chemical Company) and tert-butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate, prepared as described in (J. Med. Chem., (1988) 31, 1598-1611), were processed as described in Example 2A to provide the title  
10    compound (62% yield). <sup>1</sup>H NMR(CDCl<sub>3</sub>, 300 MHz) δ 1.44 (s, 4.5H), 1.47 (s, 4.5H), 1.95-2.08 (m, 2H), 3.46-3.58 (m, 1H), 3.64 (d, J=8.47 Hz, 0.5H), 3.75 (d, J=8.81 Hz, 0.5H), 3.91(d, J=10.51 Hz, 1H), 4.19 (dd, J=2.03, 6.78 Hz, 1H), 4.59(br s, 0.5H), 4.69 (br s, 0.5H), 5.15 (s, 1H), 7.26-7.81 (m, 2H), 8.04-8.12 (m, 1H), 8.21 (dd, J=1.70, 7.80 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 361(M+H)<sup>+</sup>.

15

Example 7B

(1S,4S)-2-(4-chloro-1-phthalazinyl)-2,5-diazabicyclo[2.2.1]heptane  
bis(4-methylbenzenesulfonate)

The product of Example 7A was processed according to the procedure described  
20    in Example 2B to provide the title compound (83% yield). <sup>1</sup>H NMR(free base, CDCl<sub>3</sub>, 300 MHz) δ 1.91 (d, J=9.93 Hz, 1H), 2.05(d, J=9.93 Hz, 1H), 3.22 (dd, J=1.84, 8.45 Hz, 1H), 3.55-3.70 (m, 2H), 3.95 (s, 1H), 4.21 (dd, J=2.21, 9.19 Hz, 1H), 5.07 (s, 1H), 7.76-7.94 (m, 2H), 8.06 (d, J=8.09 Hz, 1H), 8.15 (d, J=9.56 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 261(M+H)<sup>+</sup>; Anal. calculated for C<sub>13</sub>H<sub>13</sub>N<sub>4</sub>Cl•2.105 TsOH•0.25 H<sub>2</sub>O: C, 53.08; H, 4.87;  
25    N, 8.94. Found C, 53.14; H, 5.24; N, 8.87.

Example 8

(1S,4S)-2-(4-chloro-1-phthalazinyl)-5-methyl-2,5-diazabicyclo[2.2.1]heptane  
bis(4-methylbenzenesulfonate)

30     The product of Example 7B was processed according to the procedure described in Example 5 to provide the title compound (53% yield). <sup>1</sup>H NMR free base (CD<sub>3</sub>OD,



300 MHz)  $\delta$  2.34 (s, 3H), 2.54 (d, J=8.47 Hz, 1H), 2.68 (d, J=10.51 Hz, 1H), 3.48 (d, J=11.19 Hz, 1H), 4.28-4.45 (m, 2H), 4.59-4.66 (m, 2H), 5.34 (s, 1H), 8.08-8.15 (m, 1H), 8.23 (t, J=7.80 Hz, 1H), 8.38-8.46 (m, 2H); MS (DCI/NH<sub>3</sub>) m/z 275 (M+H)<sup>+</sup>; Anal. calculated for C<sub>14</sub>H<sub>15</sub>N<sub>4</sub>Cl•2.0 TsOH: C, 54.52; H, 5.50; N, 9.05. Found C, 54.18; H, 4.98; N, 9.08.

#### Example 9

(1S,4S)-2-(6-chloro-5-methoxycarbonyl-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane bis(4-methylbenzenesulfonate)

#### Example 9A

tert-butyl (1S,4S)-5-[6-chloro-5-(methoxycarbonyl)-3-pyridazinyl]-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

Methyl 3,6-dichloropyridazine-4-carboxylate and tert-butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate, prepared as described in (J. Med. Chem., (1988) 31, 1598-1611), were processed as described in Example 2A to provide the title compound (41% yield). <sup>1</sup>H NMR(CDCl<sub>3</sub>, 300 MHz)  $\delta$  1.42 (s, 4.5H), 1.47 (s, 4.5H), 1.90-2.11 (m, 2H), 2.86 (d, J=9.93 Hz, 1H), 3.40-3.62 (m, 2H), 3.72 (d, J=9.90 Hz, 1H), 3.93 (s, 3H), 3.51 (s, 0.5H), 4.63 (s, 0.5H), 5.05-5.15 (m, 1H), 7.49 (s, 1H); MS (DCI/NH<sub>3</sub>) m/z 368 (M+H)<sup>+</sup>.

#### Example 9B

(1S,4S)-2-(6-chloro-5-methoxycarbonyl-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane bis(4-methylbenzenesulfonate)

The product from Example 9A was processed according to the procedure described in Example 2B to provide the title compound (73% yield). <sup>1</sup>H NMR(CDCl<sub>3</sub>, 300 MHz)  $\delta$  1.88 (d, J=10.29 Hz, 1H), 2.01 (d, J=9.92 Hz, 1H), 2.81 (d, J=9.92 Hz, 1H), 3.13-3.27 (m, 2H), 3.76 (dd, J=2.21, 9.93 Hz, 1H), 3.87 (s, 1H), 3.93 (s, 3H), 5.00 (s, 1H), 7.48 (s, 1H); MS (DCI/NH<sub>3</sub>) m/z 269 (M+H)<sup>+</sup>; Anal. calculated for C<sub>11</sub>H<sub>13</sub>N<sub>4</sub>O<sub>2</sub>Cl•2.5 TsOH•1.1 H<sub>2</sub>O: C, 47.61; H, 4.93; N, 7.79. Found C, 47.61; H, 5.07; N, 7.75.

Example 103-(6-nitro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane  
dihydrochloride

5

Example 10Atert-butyl 3-(6-nitro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane-8-carboxylate

tert-Butyl 3,8-diazabicyclo[3.2.1]octane-8-carboxylate (0.4 g; 1.9 mmol), prepared as described in (J. Med. Chem., (1998) 41, 674), 5-bromo-2-nitropyridine (0.43 g; 2.27 mmol), prepared as described in (J. Am. Chem. Soc., (1945) 67, 668), and triethylamine (0.23 g; 2.27 mmol) in toluene (10 mL) were heated at reflux for 14 hours. After evaporation of the solvent, additional triethylamine (0.23 g) was added and the mixture further heated at 140 °C for 2 hours. The residue was purified on SiO<sub>2</sub> (CH<sub>2</sub>Cl<sub>2</sub>:EtOAc 9:1) to provide the title compound.

15

Example 10B3-(6-nitro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane  
dihydrochloride

The product from Example 10A was treated with 1M HCl/ether to provide the title compound (55% yield). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>, 300 MHz) δ 1.9-2.0 (m, 4H), 3.4-3.5 (m, 2H), 4.00 (d, J=11 Hz, 2H), 4.20 (br s, 2H), 7.5-7.6 (m, 1H), 8.2-8.3 (m, 2H), 9.6-9.7 (br s, 3H, exchangeable).

20

Example 113-(6-amino-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane  
trihydrochloride

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Example 11Atert-butyl 3-(6-amino-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane-8-carboxylate

30

The product from Example 10A (200 mg) was treated with 10% Pd/C (20 mg) in a 1:1 mixture of methanol:ethanol (5 mL) under a hydrogen atmosphere (1 atm). After

filtration to remove the catalyst, the filtrate was concentrated and the residue triturated with diethyl ether to afford the the title compound as a violet solid.

#### Example 11B

5

#### 3-(6-amino-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane trihydrochloride

The product from Example 11A was treated with 1M HCl/ether to provide the title compound (72% yield). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>, 300 MHz) δ 2.00 (s, 4H), 3.2 (d, J=11 Hz, 2H), 3.4 (s, J=11 Hz, 2H), 4.20 (br s, 2H), 5.80 (s, 2H, exchangeable), 7.00, (d, J=8.5 Hz, 1H), 7.40 (br s, 1H), 7.80 (br s, 2H, exchangeable), 7.9-8.0 (m, 1H), 9.10 (br s, 2H, exchangeable).

#### Example 12

15

#### 3-(6-chloro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane dihydrochloride

The product from Example 11A (0.03 g; 0.103 mmol) in 12M HCl (0.13 mL) was treated with sodium nitrite (10 mg, 0.129 mmol) at 0 °C. The reaction mixture was allowed to warm to ambient temperature and stir overnight. The mixture was neutralized by addition of NaHCO<sub>3</sub> and then extracted with CH<sub>2</sub>Cl<sub>2</sub>. The extracts were dried (Na<sub>2</sub>SO<sub>4</sub>), concentrated under reduced pressure, and the residue purified on SiO<sub>2</sub> (10% MeOH/CH<sub>2</sub>Cl<sub>2</sub>/1% NH<sub>4</sub>OH) to provide the free base. The free base was treated with 1M HCl/ether to provide the title compound (43% yield). <sup>1</sup>H NMR free base (CDCl<sub>3</sub>, 300 MHz) δ 1.8 (m, 4H), 2.1 (br s, 1H, exchangeable), 3.0 (d, K=11 Hz, 2H), 3.4-3.7 (br s, 2H), 7.0-7.2 (m, 2H), 7.9 (m, 1H).

25

#### Example 13

#### 3-(3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane dihydrochloride

The product from Example 12 was processed as described in Example 11A. The crude product was purified on SiO<sub>2</sub> (10% MeOH/CH<sub>2</sub>Cl<sub>2</sub>/1% NH<sub>4</sub>OH) and then treated with 1M HCl/ether to provide the title compound (40 % yield). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>, 300

MHz)  $\delta$  2.20 (br s, 4H), 3.5 (d,  $J=11$  Hz, 2H), 4.00 (d,  $J=11$  Hz, 2H), 4.4 (br s, 1H), 7.9-8.0 (m, 1H), 8.2-8.3 (m, 2H), 8.5 (d,  $J=3.6$  Hz, 1H); MS (DCI/ $\text{NH}_3$ )  $m/z$  190 ( $\text{M}+\text{H}$ )<sup>+</sup>.

#### Example 14

5                    3-(3-pyridazinyl)-3,8-diazabicyclo[3.2.1]octane  
                         dihydrochloride

3-(6-Chloro-3-pyridazinyl)-3,8-diazabicyclo[3.2.1]octane, prepared as described in (J. Med. Chem., (1998) 41, 674) was hydrogenated according to the procedure described in Example 11A. The crude product was purified on  $\text{SiO}_2$  (10% MeOH/ $\text{CH}_2\text{Cl}_2$ /1%  $\text{NH}_4\text{OH}$ ) and treated with 1M HCl/ether to afford the title compound (40 % yield).  $^1\text{H}$  NMR (free base,  $\text{CDCl}_3$ , 300 MHz)  $\delta$  1.9-2.0 (m, 5H), 3.1 (d,  $J=11$  Hz, 2H), 3.70 (br s, 2H), 4.0 (d,  $J=11$  Hz, 2H), 6.8 (d,  $J=8.8$  Hz, 1H), 7.2 (dd,  $J=8.8, 3.8$  Hz, 1H), 8.6 (d,  $J=3.6$  Hz, 1H); MS (DCI/ $\text{NH}_3$ )  $m/z$  191 ( $\text{M}+\text{H}$ )<sup>+</sup>.

15                    Example 15

(1R,4R)-2-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
                         4-methylbenzenesulfonate

#### Example 15A

20                    tert-butyl (1R,4R)-5-benzyl-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate  
                         (1R,4R)-2-(benzyl)-2,5-diazabicyclo[2.2.1]heptane dihydrobromide (12.4 g, 35.5 mmol), prepared as described in (J. Med. Chem., (1990) 33, 1344) and  $\text{K}_2\text{CO}_3$  (16.2 g, 117 mmol) in 100 mL of DMF were treated with di-tert-butyl dicarbonate (8.1 g, 37 mmol) at ambient temperature. After stirring for 16 hours, the mixture was filtered and the filtrate diluted with water (500 mL). The mixture was extracted with  $\text{Et}_2\text{O}$  (3x300 mL). The extracts were combined, washed with 50% brine (10x20 mL), dried over  $\text{MgSO}_4$ , and the solvent removed under reduced pressure to provide the title compound (9.7 g, 94%).  $^1\text{H}$  NMR ( $\text{DMSO}-d_6$ , 300 MHz)  $\delta$  1.62 (m, 1H), 1.79 (d,  $J=9.2$  Hz, 1H), 2.51 (m, 1H), 2.75 (m, 1H) 3.07 (t,  $J=10.2$  Hz, 1H), 3.32-3.41 (m, 2H), 3.67 (s, 1H), 4.16 (d, 9.8 Hz, 1H), 7.19-7.33 (m, 5H); MS (DCI/ $\text{NH}_3$ )  $m/z$  199 ( $\text{M}+\text{H}$ )<sup>+</sup>, 216 ( $\text{M}+\text{NH}_4$ )<sup>+</sup>.

25

30

Example 15Btert-butyl (1R,4R)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

The product from Example 15A (2 g, 6.9 mmol) in 50 mL of EtOH was treated with 10% Pd/C (150 mg) under an H<sub>2</sub> atmosphere (1 atm) for 16 hours. The mixture was  
5 filtered and the solvent was evaporated under reduced pressure to yield 1.28 g (93.4 %) of the title compound. <sup>1</sup>H NMR (DMSO-d<sub>6</sub>, MHz) δ 1.39 (s, 9H), 1.54 (d, J=5.6 Hz, 1H), 1.58 (t, J=9.5 Hz, H), 2.70-2.81 (M, 2H), 3.50 (dd, J=1.02, 10.50, 1H), 3.17 (m, 1H), 3.50 (s, 1H), 4.17 (d, J=10.17 Hz, H); MS (DCI/NH<sub>3</sub>) m/z 199 (M+H)<sup>+</sup>, 216 (M+NH<sub>4</sub>)<sup>+</sup>.

10

Example 15Ctert-butyl (1R,4R)-5-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

The product from Example 15B (0.5 g, 2.5 mmole), 2-chloro-5-iodopyridine (0.88 g, 3.35 mmole, available as described in Tetrahedron Lett., 1993, 34, 7493-7496),  
15 Pd<sub>2</sub>(dba)<sub>3</sub> (0.13 g, 0.16 mmole), BINAP (0.22 g, 0.34 mmole), and sodium tert-butoxide (0.325 g, 3.57 mmole) in anhydrous toluene (10 mL) were heated to 70 °C for 16 hours. The mixture was filtered, concentrated under reduced pressure, and the residue purified by chromatography (silica gel; hexane:EtOAc, 9:1 to 1:1) to provide the title compound (0.522 g, 67 %). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>, 300 MHz) δ 1.33-1.38 (m 9H), 2.50 (br s, 2H),  
20 3.02 (m, 1H), 3.16 (d, J=10.17 Hz, 1H), 3.27 (m, 1H), 3.53 (m, 1H), 4.43 (m, 1H), 4.58 (br, s 1H), 7.11 (dd, J=3.05, 8.81 Hz, 1H), 7.24 (d, J=27.46 Hz, 1H), 7.77 (d, J=3.05 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 310 (M+H)<sup>+</sup>.

Example 15D(1R,4R)-2-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane4-methylbenzenesulfonate

The product of Example 15C (478 mg, 1.5 mmole) in CH<sub>2</sub>Cl<sub>2</sub> (3 mL) was treated with trifluoroacetic acid (3 mL). After stirring for one hour at ambient temperature, the solvent was removed and the residue dissolved in saturated Na<sub>2</sub>CO<sub>3</sub> (20 mL). The  
30 mixture was extracted with EtOAc (4 X 20mL), dried over MgSO<sub>4</sub>, concentrated under reduced pressure, and the residue purified (SiO<sub>2</sub>; 10% MeOH/CHCl<sub>3</sub>/1% NH<sub>4</sub>OH) to

provide the free base. The free base was treated with TsOH in hot EtOAc to provide the title compound (451 mg, 71%).  $[\alpha]_D^{23}$  -8.21 (c 0.21, MeOH);  $^1\text{H}$  NMR (DMSO- $d_6$ , 300 MHz)  $\delta$  1.93 (d,  $J=11.52$  Hz, 1H), 2.14 (d  $J=11.19$  Hz 1H), 2.29 (s, 3H), 3.13-3.31 (m, 3H), 3.61 (dd,  $J=2.37, 10.85$ , 1H), 4.48 (s, 1H), 4.68 (s, 1H), 7.13 (d,  $J=8.48$  Hz, 2H),  
5 7.17 (dd,  $J=3.05, 8.62$  Hz, 1H), 7.31 (d,  $J=8.82$ , 1H), 7.49 (d  $J=7.66$  Hz, 2H), 7.85 (d  $J=3.39$  Hz, 1H); MS (DCI/ $\text{NH}_3$ )  $m/z$  210 ( $M+H$ ) $^+$ ; Anal. Calcd for  $\text{C}_{10}\text{H}_{12}\text{N}_3\text{Cl}\cdot\text{C}_7\text{H}_8\text{O}_3\text{S}$ : C, 53.47; H, 5.28; N, 11.00. Found: C, 53.43; H, 5.36; N, 10.97.

#### Example 16

10 (1R,4R)-2-(6-chloro-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane  
bis(4-methylbenzenesulfonate)

#### Example 16A

tert-butyl (1R,4R)-5-(6-chloro-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane-2-  
15 carboxylate

The product from Example 15B and 3,6-dichloropyridazine (purchased from Aldrich Chemical Co.) were processed as described in Example 2A to provide the title compound.  $^1\text{H}$  NMR (DMSO- $d_6$ , 300 MHz)  $\delta$  1.48 (m 9H), 2.93 (br, s 2H), 3.18 (d,  $J=12.17$  Hz, 1H), 3.3-3.51 (m, 2H), 3.55 (m, 1H), 4.49 (m, 1H), 4.86 (br, s 1H), 7.12 (m,  
20 1H), 7.51 (d,  $J=9.49$  Hz, 1H); MS (DCI/ $\text{NH}_3$ )  $m/z$  311 ( $M+H$ ) $^+$ .

#### Example 16B

(1R,4R)-2-(6-chloro-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane  
bis(4-methylbenzenesulfonate)

25 The product from Example 16A (353 mg, 1.1 mmole) and para-toluenesulfonic acid (660 mg 3.5 mmole) in EtOAc (10 mL) were heated at 70 °C for one hour and then cooled to ambient temperature. The obtained solid was washed with EtOAc (2x10 mL), ether (2x10 mL), and dried under reduced pressure to provide the title compound (597 mg, 94.7%).  $[\alpha]_D^{23}$  +59.3 (c 1.0, MeOH);  $^1\text{H}$  NMR (DMSO- $d_6$ , 300 MHz)  $\delta$  1.96 (d,  $J=10.51$  Hz, 1H), 2.17 (d,  $J=10.17$  Hz 1H), 2.29 (s, 6H), 3.24-3.28 (m, 2H), 3.56-3.67  
30 (m, 2H), 4.53 (s, 1H), 4.95 (s, 1H), 7.11 (d,  $J=7.79$ , 4H), 7.21 (d,  $J=9.41$  Hz, 1H), 7.49

(d, J=8.11 Hz, 4H), 7.62 (d, J=9.49 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 211 (M+H)<sup>+</sup>; Anal. Calcd for C<sub>9</sub>H<sub>11</sub>N<sub>4</sub>Cl•2C<sub>7</sub>H<sub>8</sub>O<sub>3</sub>S: C, 49.77; H, 4.90; N, 10.09. Found: C, 49.77; H, 4.99; N, 9.96.

5

Example 17

(1S,4S)-2-(3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

Example 17A

10 tert-butyl (1S,4S)-5-(3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate  
tert-Butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate, prepared as described in J. Med. Chem., (1988) 31, 1598-1611, and 3-bromopyridine (Aldrich Chemical Company) were processed as described in Example 1A to provide the title compound (99% yield). <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 1.42 (s, 4.5H), 1.48 (s, 4.5H),  
15 1.91-2.03 (m, 2H), 3.14 (d, J=14.7 Hz, 0.5H), 3.23 (d, J=14.7 Hz, 0.5H), 3.37-3.48 (m, 2H), 3.60 (d, 8.45 Hz, 1H), 4.41 (s, 1H), 4.53 (s, 0.5H), 4.67 (s, 0.5H), 6.85 (dd, J=2.94, 8.83 Hz, 1H), 7.09-7.21 (m, 1H), 7.95-8.06 (m, 2H); MS (DCI/NH<sub>3</sub>) m/z 276 (M+H)<sup>+</sup>.

Example 17B

20 (1S,4S)-2-(3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

The product from Example 17A was processed as described in Example 1B to provide the title compound (65% yield). <sup>1</sup>H NMR (CDCl<sub>3</sub>, free base, 300 MHz) δ 1.82-1.98 (m, 2H), 3.01 (d, J=12.0 Hz, 1H), 3.08 (s, 2H), 3.67 (dd, J=2.0, 11.5 Hz, 1H), 3.76  
25 (s, 1H), 4.32 (s, 1H), 6.78-6.85 (m, 1H), 7.05-7.13 (m, 1H), 7.82-8.01 (m, 2H); MS (DCI/NH<sub>3</sub>) m/z 176 (M+H)<sup>+</sup>, 193 (M+NH<sub>4</sub>)<sup>+</sup>; Anal. Calcd for C<sub>10</sub>H<sub>13</sub>N<sub>3</sub>•1.0 TsOH•0.4H<sub>2</sub>O: C, 57.58; H, 6.20; N, 11.85. Found C, 57.85; H, 6.33; N, 11.47.

Example 18

30 (1S,4S)-2-(5-chloro-2-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
dihydrochloride

Example 18A

tert-butyl (1S,4S)-5-(5-chloro-2-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

tert-Butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate, prepared as  
5 described in (J. Med. Chem., (1988) 31, 1598-1611), and commercially available 2,5-  
dichloropyridine were processed as described in Example 2A to provide the title  
compound (99% yield).

Example 18B

10 (1S,4S)-2-(5-chloro-2-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
dihydrochloride

The product from Example 18A was treated with HCl in ether to afford the  
dihydrochloride salt. <sup>1</sup>H NMR (DMSO-d<sub>6</sub>, 300 MHz) δ 2.00(m,2H), 3.2-3.3(m,4H), 4.6-  
4.8(m,2H) 6.80(d,J=7.4Hz, 1H), 7.8(dd, J=7.5, 3.1Hz, 1H), 8.2(d, J=3.1 Hz, 1H), 9.2 (br.  
15 s. 1H), 9.8 (br. s., 1H); MS (DCI/NH<sub>3</sub>) m/z 210, 212 (M+H)<sup>+</sup>.

Example 19

3-(5-chloro-2-pyridinyl)-3,8-diazabicyclo[3.2.1]octane  
dihydrochloride

20 Example 19A

tert-butyl 3-(5-chloro-2-pyridinyl)-3,8-diazabicyclo[3.2.1]octane-8-carboxylate

tert-Butyl 3,8-diazabicyclo[3.2.1]octane-8-carboxylate, prepared as described in  
(J. Med. Chem., (1998) 41, 674), and 2,5-dichloropyridine were processed as described  
in Example 10A to provide the title compound.

25

Example 19B

3-(5-chloro-2-pyridinyl)-3,8-diazabicyclo[3.2.1]octane  
dihydrochloride

The product from Example 19A was processed as described in Example 10B to  
30 provide the title compound. <sup>1</sup>H NMR (DMSO-d<sub>6</sub>, 300 MHz) δ 1.9-2.0(m, 4H), 3.2 (d,



J=11 Hz, 2H), 4.0-4.2 (m, 4H), 7.0 (d, J=7.1 Hz, 1H), 7.8 (dd, J=7.5, 3.1 Hz, 1H), 8.2 (d, J=3.1 Hz, 1H), 9.4 (br. s. 2H); MS (DCI/NH<sub>3</sub>) m/z 224, 226 (M+H)<sup>+</sup>.

#### Example 20

5                    (1R,4R)-2-(3-pyridinylmethyl)-2,5-diazabicyclo[2.2.1]heptane  
                         trihydrobromide

#### Example 20A

10                    (1R,4R)-2-[(4-methylphenyl)sulfonyl]-5-(3-pyridinylmethyl)-2,5-  
                         diazabicyclo[2.2.1]heptane

                         ((2R,4S)-1-[(4-Methylphenyl)sulfonyl]-4-[[4-methylphenyl)sulfonyl]oxy}pyrrolidinyl)methyl 4-methylbenzenesulfonate (1.5 g, 2.6 mmol), prepared as described in (J. Med. Chem. (1990) 33, 1344) and 3-(aminomethyl)pyridine (1.0 g, 9.3 mmol) in 20 mL of toluene were heated under reflux  
15 for 16 hours. The mixture was cooled, filtered, and the filter cake was washed with 20 mL of toluene. The filtrate was concentrated under reduced pressure and the residue was purified by chromatography (silica gel; hexanes:EtOAc, 9:1 to 1:1) to provide the title compound (410 mg, 46%). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>, 300 MHz) δ 0.86 (d, J=8.5 Hz, 1H), 1.62 (d, J=9.7 Hz, 1H), 2.42 (s, 3H), 2.44 (m, 1H), 2.66 (dd, J=2.4, 9.5 Hz, 1H), 2.99 (dd, J=2.0, 9.5 Hz, 1H), 3.39-3.48 (m, 2H), 3.62-3.41 (d, J=9.5 Hz, 1H), 4.23 (br s, 1H), 4.35  
20 (t, J=5.1 Hz, 1H), 7.31 (m, 1H), 7.43-7.46 (m, 2H), 7.62 (m, 1H), 7.71-7.74 (m, 2H), 8.31-8.43 (m, 2H).

#### Example 20B

25                    (1R,4R)-2-(3-pyridinylmethyl)-2,5-diazabicyclo[2.2.1]heptane  
                         trihydrobromide

                         The product from Example 20A (320 mg, 0.9 mmol) in acetic acid (3.4 mL) and 33% HBr/acetic acid (7 mL) was heated to 70 °C for 18 hours. After cooling to ambient temperature, the precipitate was filtered, washed with ether, and dried. The resulting  
30 solids were recrystallized from EtOH/EtOAc to provide the title compound (332 mg, 80%). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>, 300 MHz) δ 2.22 (m, 1H), 2.47 (m, 1H), 3.29-3.48 (m, 2H),

3.35 (m, 1H), 3.69 (m, 1H), 4.19-4.53 (m, 2H), 5.59 (m, 2H), 8.05 (m, 1H), 8.62 (m, 1H), 8.78-8.88 (m, 2H); MS (DCI/NH<sub>3</sub>) m/z 190 (M+H)<sup>+</sup>; Anal. Calcd for C<sub>11</sub>H<sub>15</sub>N<sub>3</sub>•3.0 HBr•0.1 H<sub>2</sub>O: C, 30.46; H, 4.23; N, 9.69. Found: C, 30.83; H, 4.25; N, 9.30.

5

Example 21

(1S,4S)-2-[5-(benzyloxy)-3-pyridinyl]-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

Example 21A

10 tert-butyl (1S,4S)-5-[5-(benzyloxy)-3-pyridinyl]-2,5-diazabicyclo[2.2.1]heptane-2-  
carboxylate

tert-Butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate, prepared as described in (J. Med. Chem., (1988) 31, 1598-1611) and 3-(benzyloxy)-5-bromopyridine, prepared as described in (US 5,733,912) were coupled according to the procedure described in Example 1A to provide the title compound. MS (DCI/NH<sub>3</sub>) m/z 382 (M+H)<sup>+</sup>.

15

Example 21B

(1S,4S)-2-[5-(benzyloxy)-3-pyridinyl]-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

20

The product of Example 21A was processed as described in Example 2B to provide the title compound. <sup>1</sup>H NMR(CDCl<sub>3</sub>, 300MHz) δ 1.78-2.00(m, 4H), 2.97(d, J=12.0 Hz, 1H), 3.05(s, 2H), 3.62(dd, J=3.0, 10.0 Hz, 1H), 3.81(s, 1H), 4.28(s, 1H), 6.42(dd, J=2.0,8.0 Hz, 1H), 7.31-7.51(m, 5H), 7.65(d, J=3.0Hz, 1H), 7.78(d, J=3.0Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 282 (M+H)<sup>+</sup>; Anal. calculated for C<sub>24</sub>H<sub>27</sub>N<sub>3</sub>O<sub>4</sub>S•0.30 TsOH•0.55 H<sub>2</sub>O: C, 60.86; H, 5.97; N, 8.16. Found C, 60.83; H, 6.00; N, 8.12.

25

Example 22

(1S,4S)-2-[5-hydroxy-3-pyridinyl]-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

30

Example 22Atert-butyl (1S,4S)-5-(5-hydroxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

The product from Example 21A (0.50 g, 1.31 mmol) in EtOH (15 mL) was  
5 treated with 10%Pd/C (0.02g) under a hydrogen atmosphere (1atm) at 40 °C for 6 hours.  
The reaction mixture was allowed to cool to ambient temperature and the catalyst was  
removed by filtration. The filtrate was diluted with diethyl ether (125 mL), washed with  
brine, dried (MgSO<sub>4</sub>), and concentrated under reduced pressure. The residue was  
purified by chromatography on SiO<sub>2</sub> (5%MeOH/CH<sub>2</sub>Cl<sub>2</sub>) to provide the title compound  
10 (0.345 g, 90% yield) as a yellow oil. MS(DCI/NH<sub>3</sub>) m/z 292 (M+H)<sup>+</sup>.

Example 22B(1S,4S)-2-[5-hydroxy-3-pyridinyl]-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

15 The product from Example 22A was processed as described in Example 2B to  
provide the title compound. <sup>1</sup>H NMR (MeOD, 300 MHz) δ 2.07 (d, J=12.0 Hz, 1H),  
2.28(d, J=13.0 Hz, 1H), 3.32-3.42 (m, 3H), 3.71 (dd, J=4.0, 10.0 Hz, 1H), 4.51 (s, 1H),  
4.68 (s, 1H), 6.62 (t, J=2.0 Hz, 1H), 7.51-7.56 (m, 2H); MS (DCI/NH<sub>3</sub>) m/z 192 (M+H)<sup>+</sup>;  
Anal. calculated for C<sub>17</sub>H<sub>21</sub>N<sub>3</sub>O<sub>4</sub>S•0.55 TsOH•2.35 H<sub>2</sub>O: C, 50.04; H, 6.06; N, 8.40.  
20 Found C, 50.09, H, 6.35; N, 8.38.

Example 23(1S,4S)-2-(6-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

25

Example 23Atert-butyl (1S,4S)-5-(6-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

tert-Butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate, prepared as  
described in (J. Med. Chem., (1988) 31, 1598-1611), and 5-bromo-2-methyl-pyridine  
30 (purchased from Emka Chemie) were coupled according to the procedure described in  
Example 1A to provide the title product. MS (DCI/NH<sub>3</sub>) m/z 290 (M+H)<sup>+</sup>.

Example 23B(1S,4S)-2-(6-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane4-methylbenzenesulfonate

5        The product from Example 23A was processed as described in Example 2B to provide the title compound. <sup>1</sup>H NMR(CDCl<sub>3</sub>, 300 MHz) δ 1.84 (d, J=9.0Hz, 1H), 1.93 (d, J=9.0Hz, 1H), 2.42 (s, 3H), 2.92 (d, J=7.0Hz, 1H), 3.03-3.10 (m, 2H), 3.65 (dd, J=2.0, 6.0 Hz, 1H), 3.78 (s, 1H), 4.28 (s, 1H), 6.78 (dd, J=4.0, 7.0 Hz, 1H), 6.97 (d, J=4.0 Hz, 1H), 7.85 (d, J=2.0 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 190 (M+H)<sup>+</sup>; Anal. calculated for C<sub>18</sub>H<sub>23</sub>N<sub>3</sub>O<sub>3</sub>S•0.5 TsOH•0.5 H<sub>2</sub>O: C, 56.56; H, 6.18; N, 9.20. Found C, 56.57; H, 6.03; N, 9.28.

Example 24(1R,4R)-2-(3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane

15        4-methylbenzenesulfonate

Example 24Atert-butyl (1R,4R)-5-(3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

20        The product from Example 15B and 3-bromopyridine (available from Aldrich Chemical Co.) were coupled according to the procedure described in Example 15C to provide the title compound. MS (DCI/NH<sub>3</sub>) m/z 276 (M+H)<sup>+</sup>.

Example 24B(1R,4R)-2-(3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane

25        4-methylbenzenesulfonate

30        The product from Example 24A was processed as described in Example 2B to provide the title compound. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 1.90 (dd, J=12.0, 30.0 Hz, 2H), 2.98 (d, J=9.0 Hz, 1H), 3.08 (s, 2H), 3.63 (dd, J=3.0, 10.0 Hz, 1H), 3.82 (s, 1H), 4.32 (s, 1H), 6.78-6.84 (m, 1H), 7.08-7.15 (m, 1H), 7.95 (dd, 2.0, 8.0 Hz, 1H), 8.00 (d, J=3.0Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 176 (M+H)<sup>+</sup>; Anal. calculated for C<sub>17</sub>H<sub>21</sub>N<sub>3</sub>O<sub>3</sub>S•0.45 H<sub>2</sub>O: C, 57.43; H, 6.21; N, 11.82. Found C, 57.64; H, 6.11; N, 11.43.

Example 25

(1R,4R)-2-(3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

5

Example 25A

tert-butyl (1R,4R)-5-(3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

The product from Example 16A was process according to the procedure described in Example 29A to provide the title compound. MS (DCI/NH<sub>3</sub>) m/z 277 (M+H)<sup>+</sup>.

10

Example 25B

(1R,4R)-2-(3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

15

The product from Example 25A was processed as described in Example 2B to provide the title compound. <sup>1</sup>H NMR (MeOH, 300 MHz) δ 2.11(d, J=12.0 Hz, 1H), 2.26-2.39(m, 3H), 3.65-3.82 (m, 2H), 4.60 (s, 1H), 5.09 (s, 1H), 7.30 (dd, J=1.0, 9.0 Hz, 1H), 7.57-7.65(m, 1H), 8.56 (dd, J=1.0,6.0 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 176 (M+H)<sup>+</sup>; Anal. calculated for C<sub>16</sub>H<sub>20</sub>N<sub>4</sub>O<sub>3</sub>S•0.25 TsOH•0.85 H<sub>2</sub>O: C, 52.41; H, 5.87; N, 13.77. Found C, 52.45; H, 5.88; N, 13.69.

20

Example 27

(1R,4R)-2-(6-chloro-3-pyridinyl)-5-cyanomethyl-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

25

The product from Example 15D (140 mg, 0.37 mmole) in DMF (5 mL) was treated with triethylamine (0.26 mL, 1.8 mmole) and bromoacetonitrile (0.03 mL, 0.43 mmole) under a nitrogen atmosphere. After stirring for 72 hours at ambient temperature, the reaction mixture was poured into saturated. aqueous Na<sub>2</sub>CO<sub>3</sub> (30 mL) and extracted with ether (5x50 mL). The organic phase was dried (MgSO<sub>4</sub>) and concentrated under reduced pressure. The residue was purified on SiO<sub>2</sub> (CHCl<sub>3</sub> /MeOH/ NH<sub>4</sub>OH 95:4.5:0.5)

30

and combined with 4-methylbenzenesulfonic acid (21 mg, 0.11 mmole) to provide the title compound (47 mg, 30% yield). <sup>1</sup>H NMR (D<sub>2</sub>O, 300 MHz) δ 2.14 (m, 2H), 2.39 (s, 3H), 3.34-3.48 (m, 2H), 3.36 (d, J=9.03 Hz 1H), 3.62 (m, 1H), 3.93-3.95 (m, 2H), 4.10 (br s, 1H), 4.52 (br s, 1H), 7.17 (dd, J=2.84, 7.72 Hz, 1H) 7.28-7.38 (m, 3H), 7.69 (d, J=8.11 Hz, 2H) 7.77 (d, J=2.94 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 249 (M+H)<sup>+</sup>, 266 (M+NH<sub>4</sub>)<sup>+</sup>; Anal calculated for C<sub>12</sub>H<sub>13</sub>N<sub>4</sub>Cl • C<sub>7</sub>H<sub>8</sub>O<sub>3</sub>S • 0.1 H<sub>2</sub>O: C, 53.99; H, 5.05; N, 13.25. Found C, 53.99; H, 5.19; N, 13.19.

10

Example 28(1S,4S)-2-(6-nitro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane

The product from Example 3A was treated with trifluoroacetic acid:methylene chloride (1:2) at ambient temperature for 2 hours. The volatiles were removed under reduced pressure, and the residue was purified on SiO<sub>2</sub> (5%MeOH/CH<sub>2</sub>Cl<sub>2</sub>/1%NH<sub>4</sub>OH) to provide the title compound as a yellow gum. MS (DCI/NH<sub>3</sub>) m/z 221 (M+H)<sup>+</sup>, 238 (M+NH<sub>4</sub>)<sup>+</sup>.

15

Example 29(1S,4S)-2-(3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane

20

4-methylbenzenesulfonateExample 29Atert-butyl (1S,4S)-5-(3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

25

The product from Example 2A (0.885 g, 2.85 mmol) in MeOH (14 mL) and triethylamine (0.55 mL) was treated with 10%Pd/C (0.02 g) and stirred under a hydrogen atmosphere (60 psi) at 50 °C for 80 minutes. The catalyst was removed by filtration and the filtrate was concentrated. The residue was purified on SiO<sub>2</sub> (5%MeOH/CH<sub>2</sub>Cl<sub>2</sub>) to provide the title compound (0.72 g, 92%) as a white solid. MS (DCI/NH<sub>3</sub>) m/z 276 (M+H)<sup>+</sup>.

30

Example 29B(1S,4S)-2-(3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

The product from Example 29A was processed as described in Example 2B to  
5 provide the title compound. <sup>1</sup>H NMR (MeOH, 300 MHz) δ 2.13(d, J=13.0 Hz, 1H),  
2.28-2.40 (m, 3H), 3.68-3.87 (m, 2H), 4.62 (s, 1H), 5.11 (s, 1H), 7.36 (dd, J=1.0,9.0 Hz,  
1H), 7.60-7.68 (m, 1H), 8.60 (dd, J=1.0,5.0 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 176 (M+H)<sup>+</sup>;  
Anal. calculated for C<sub>16</sub>H<sub>20</sub>N<sub>4</sub>O<sub>3</sub>S•0.25 TsOH•0.85 H<sub>2</sub>O: C, 52.34; H, 5.85; N, 13.49.  
Found C, 52.29; H, 6.03; N, 13.52.

10

Example 30(1S,4S)-2-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
bis(4-methylbenzenesulfonate)

15

Example 30Atert-butyl (1S,4S)-5-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

tert-Butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate (0.300 g, 1.01  
mmol), prepared as described in (J. Med. Chem., (1988) 31, 1598-1611), in anhydrous  
toluene (30ml) was treated with 2-fluoro-5-iodopyridine (0.34g, 1.52 mmol), available as  
20 described in (US 5,733,912), Pd<sub>2</sub>(dba)<sub>3</sub> (0.028 g, 0.03 mmol), (S)-(-)-2-  
(diphenylphosphino)-2'-methoxy-1,1'-binaphthyl (0.028 g, 0.06 mmol), available from  
Strem Chemicals, and sodium tert-butoxide (0.248 g, 2.58 mmol). The reaction mixture  
was heated at 80°C for 5 hours. The reaction mixture was poured into diethyl ether (100  
mL), washed with brine (100ml), dried (MgSO<sub>4</sub>), and concentrated under reduced  
25 pressure. The residue was purified by chromatography on SiO<sub>2</sub> (3%MeOH/CH<sub>2</sub>Cl<sub>2</sub>) to  
provide the title compound (0.095g, 21% yield) as a yellow oil. MS (DCI/NH<sub>3</sub>) m/z 276  
(M+H)<sup>+</sup>.

30

Example 30B(1S,4S)-2-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
bis(4-methylbenzenesulfonate)

The product from Example 30A was processed as described in Example 2B to provide the title compound. <sup>1</sup>H NMR(MeOD, 300 MHz) δ 2.06 (d, J=12.0 Hz, 1H), 2.29 (d, J=12.0 Hz, 1H), 3.25-3.30 (m, 1H), 3.35 (s, 2H), 3.73 (dd, J=3.0, 12.0 Hz, 1H), 4.50 (s, 1H), 4.68(3, 1H), 6.96 (dd, J=3.0, 9.0 Hz, 1H), 7.28-7.38 (m, 1H), 7.52-7.54 (m, 1H);  
5 MS (DCI/NH<sub>3</sub>) m/z 194 (M+H)<sup>+</sup>; Anal. calculated for C<sub>24</sub>H<sub>28</sub>N<sub>3</sub>O<sub>6</sub>S<sub>2</sub>F•0.75 TsOH•1.15 H<sub>2</sub>O: C, 51.10; H, 5.32; N, 6.11. Found C, 51.11; H, 5.54; N, 6.10.

#### Example 31

10 (1S,4S)-2-(5-bromo-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

#### Example 31A

tert-butyl (1S,4S)-5-(5-bromo-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate  
tert-Butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate, prepared as  
15 described in (J. Med. Chem., (1988) 31, 1598-1611), and 3,5-dibromopyridine  
(purchased from Avocado Research Chemicals, Ltd.) were coupled according to the  
procedure described in Example 1A to provide the title compound. MS (DCI/NH<sub>3</sub>) m/z  
354 (M+H)<sup>+</sup>.

#### 20 Example 31B

(1S,4S)-2-(5-bromo-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

The product of Example 31A was processed as described in Example 2B to provide the title compound. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 1.92-2.10 (m, 2H), 3.21 (s,  
25 2H), 3.60-3.71 (m, 2H), 4.05 (s, 1H), 4.38 (s, 1H), 6.97 (t, J=1.0 Hz, 1H), 7.90 (d, J=2.0  
Hz, 1H), 8.03 (d, J=1.0 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 254 (M+H)<sup>+</sup>; Anal. calculated for  
C<sub>17</sub>H<sub>20</sub>N<sub>3</sub>O<sub>3</sub>SBr•0.30 TsOH: C, 47.99; H, 4.72; N, 8.79. Found C, 48.02; H, 4.95; N,  
8.87.

#### 30 Example 32

(1S,4S)-2-(5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane



4-methylbenzenesulfonateExample 32Atert-butyl (1S,4S)-5-(5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

- 5       The product of Example 31A (2.89g, 8.2 mmol) in anhydrous/degassed DMF (60ml) was treated with Zn(CN)<sub>2</sub> (0.481g, 4.1 mmol), and tetrakis(triphenylphosphine)-palladium(0) (0.95g, 0.8 mmol). The mixture was heated at 80°C for 16 hours under a nitrogen atmosphere. The reaction mixture was allowed to cool to ambient temperature and poured into diethyl ether (150ml). The organics were washed with brine/H<sub>2</sub>O (1/1)
- 10       (200ml), dried (MgSO<sub>4</sub>), and concentrated under reduced pressure. The residue was purified on SiO<sub>2</sub> (5% MeOH/CH<sub>2</sub>Cl<sub>2</sub>) to provide the title compound (1.90 g, 77% yield) as a white solid. MS (DCI/NH<sub>3</sub>) m/z 301 (M+H)<sup>+</sup>.

Example 32B

- 15       (1S,4S)-2-(5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

- The product from Example 32A was processed as described in Example 2B to provide the title compound. <sup>1</sup>H NMR (MeOD, 300 MHz) δ 2.0 (d, J=13.0 Hz, 1H), 2.21 (d, J=13.0 Hz, 1H), 3.38 (s, 2H), 3.42 (d, J=1.0 Hz, 1H), 3.75 (dd, J=3.0, 12.0 Hz, 1H),
- 20       4.56 (s, 1H), 4.82 (s, 1H), 7.48 (t, J=1.0 Hz, 1H), 8.19-8.31 (m, 2H); MS (DCI/NH<sub>3</sub>) m/z 201 (M+H)<sup>+</sup>; Anal. calculated for C<sub>18</sub>H<sub>20</sub>N<sub>4</sub>O<sub>3</sub>S: C, 58.05; H, 5.41; N, 15.04. Found C, 57.84; H, 5.47; N, 14.81.

Example 33

- 25       (1R,4R)-2-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

Example 33Atert-butyl (1R,4R)-5-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

The product from Example 15B and 2-fluoro-5-iodopyridine were processed as described in Example 30A to provide the title compound. MS (DCI/NH<sub>3</sub>) m/z 294 (M+H)<sup>+</sup>.

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Example 33B

(1R,4R)-2-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

The product of Example 33A was processed as described in Example 2B to provide the title compound. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 1.75 (d, J=12.0 Hz, 1H), 1.96 (d, J=12.0 Hz, 1H), 2.92 (d, J=9.0 Hz, 1H), 3.07 (s, 2H), 3.66 (dd, J=3.0, 9.0 Hz, 1H), 3.81 (s, 1H), 4.26 (s, 1H), 6.78 (dd, J=1.0, 6.0 Hz, 1H), 6.92-7.0 (m, 1H), 7.45 (t, J=1.0 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 194 (M+H)<sup>+</sup>, 211 (M+NH<sub>4</sub>)<sup>+</sup>; Anal. calculated for C<sub>17</sub>H<sub>20</sub>N<sub>3</sub>O<sub>3</sub>SF: C, 55.20; H, 5.59; N, 11.36. Found C, 55.21; H, 5.61; N, 11.13.

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Example 34

(1S,4S)-2-(5-aminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
trihydrochloride

Example 34A

tert-butyl (1S,4S)-5-(5-aminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-  
carboxylate

The product from Example 32A (0.267g, 0.89 mmol) in 30% NH<sub>3</sub>/methanol was treated with Raney-Nickel (0.10g). The reaction mixture was stirred at ambient temperature under a hydrogen atmosphere (60 psi) for 4 hours. The mixture was filtered and concentrated under reduced pressure. The residue was purified by chromatography (SiO<sub>2</sub>; 10% MeOH/CH<sub>2</sub>Cl<sub>2</sub>/1% NH<sub>4</sub>OH) to provide the title compound (0.199 g, 73% yield) as a white solid. MS (DCI/NH<sub>3</sub>) m/z 305 (M+H)<sup>+</sup>.

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Example 34B

(1S,4S)-2-(5-aminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
trihydrochloride

The product from Example 34A (0.199 g, 0.65 mmol) in EtOH (5 mL) was treated with 4N HCl/dioxane (5 mL). After stirring at ambient temperature for 1 hour, the volatiles were removed under reduced pressure to provide the title compound (0.042 g, 20% yield) as a white solid. <sup>1</sup>H NMR(CDCl<sub>3</sub>, 300 MHz) δ 2.18 (d, J=12.0 Hz, 1H), 2.34 (d, J=12.0 Hz, 1H), 3.45-3.58 (m, 3H), 3.83 (d, J=15.0 Hz, 1H), 4.32 (s, 2H), 4.68 (s, 1H), 4.89 (s, 1H), 7.68 (s, 1H), 8.11 (s, 1H), 8.15 (s, 1H); MS (DCI/NH<sub>3</sub>) m/z 205 (M+H)<sup>+</sup>; Anal. calculated for C<sub>11</sub>H<sub>16</sub>N<sub>4</sub>•3.6 HCl•0.45 EtOH: C, 40.12; H, 6.31; N, 15.73. Found C, 40.22; H, 6.20; N, 15.72.

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Example 35

2-(6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane  
trihydrochloride

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Example 35A

benzyl 3-oxo-2,6-diazabicyclo[3.2.1]octane-6-carboxylate

Benzyl 5-oxo-2-azabicyclo[2.2.1]heptane-2-carboxylate (2.46 g, 10.0 mmol), prepared according to the procedures described by (Carroll, F. I.; et. al., J. Med. Chem. (1992) 35, 2184), in 50 mL of 95% aqueous ethanol at ambient temperature was treated with sodium acetate (2.47 g, 30.1 mmol) and hydroxylamine hydrochloride (3.48 g, 50.1 mmol). After 45 minutes, the mixture was concentrated under reduced pressure and the residue was diluted with saturated aqueous NaHCO<sub>3</sub> and extracted with EtOAc. The organic extract was dried (MgSO<sub>4</sub>) and concentrated to afford 2.50 grams (96%) of a mixture of the desired oximes as a white solid. A portion of this material (1.57 g, 6.03 mmol) was stirred in a 5:1 solution of CH<sub>2</sub>Cl<sub>2</sub>/trimethylsilylpolyposphosphate for 12 hours at ambient temperature. The solution was diluted with H<sub>2</sub>O and extracted twice with EtOAc. The combined organic extracts were dried (MgSO<sub>4</sub>) and concentrated under reduced pressure. The residue was purified by chromatography (silica gel; 95:5 CH<sub>2</sub>Cl<sub>2</sub>/MeOH) to provide 1.08 grams (68%) of the title compound as a white solid. MS (DCI/NH<sub>3</sub>) m/z 261 (M+H)<sup>+</sup>, 278 (M+NH<sub>4</sub>)<sup>+</sup>.

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Example 35B

benzyl 2,6-diazabicyclo[3.2.1]octane-6-carboxylate

The product from example 35A (800 mg, 3.07 mmol) in THF (12 mL) at 0 °C was treated dropwise with a 2.0 M solution of borane-methyl sulfide complex in THF (3.4 mL, 6.8 mmol). The solution was stirred for 14 hours at ambient temperature, then re-cooled to 0 °C and quenched by the careful addition of MeOH and concentrated under reduced pressure. The residue was dissolved in toluene (12 mL) and treated with n-propylamine (1.7 mL). The mixture was stirred for 3 hours at 60 °C, allowed to cool to ambient temperature, and concentrated under reduced pressure. The residue was diluted with saturated aqueous NaHCO<sub>3</sub> and extracted with CH<sub>2</sub>Cl<sub>2</sub> (4X). The organic extracts were combined, dried (K<sub>2</sub>CO<sub>3</sub>), and concentrated. The residue was purified by chromatography (silica gel; 90:10:1 CH<sub>2</sub>Cl<sub>2</sub>/MeOH/NH<sub>4</sub>OH) to provide 453 mg (60%) of the title compound as a colorless oil. MS (DCI/NH<sub>3</sub>) m/z 247 (M+H)<sup>+</sup>.

Example 35Cbenzyl 2-(6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane-6-carboxylate

The product from Example 35B and 2-chloro-5-iodopyridine were processed as described in Example 1A to provide the title compound (30% yield) as a light yellow oil. MS (DCI/NH<sub>3</sub>) m/z 358, 360 (M+H)<sup>+</sup>.

Example 35D2-(6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane trihydrochloride

The product from Example 35C (62 mg, 0.17 mmol) in acetonitrile (3 mL) at 0 °C was treated with iodotrimethylsilane (37 mL, 0.26 mmol). The solution was stirred at 0 °C for 3 hours, quenched with MeOH, and concentrated under reduced pressure. The residue was diluted with 1N aqueous HCl and extracted with EtOAc (2X). The aqueous phase was basified with 10% aqueous NaOH and extracted with 3:1 CH<sub>2</sub>Cl<sub>2</sub>/iPrOH (4X). The extracts were combined, dried (K<sub>2</sub>CO<sub>3</sub>), and concentrated to provide a light yellow oil. The oil was diluted with EtOH and treated with a solution of HCl in diethyl ether. The resulting precipitate was collected, triturated with diethyl ether, and dried under high vacuum to provide the title compound as a light yellow solid. <sup>1</sup>H NMR (DMSO-d<sub>6</sub>, 300

Hz)  $\delta$  1.80-2.02 (m, 4H), 3.00 (m, 1H), 3.34-3.40 (m, 2H), 3.60 (m, 1H), 4.15 (m, 1H), 4.68 (m, 1H), 7.33 (d,  $J=8.8$  Hz, 1H), 7.43 (dd,  $J=3.3, 8.8$  Hz, 1H), 8.08 (d,  $J=3.0$  Hz, 1H); MS (CI/NH<sub>3</sub>)  $m/z$  224, 226 (M+H)<sup>+</sup>; Anal. Calcd for C<sub>11</sub>H<sub>14</sub>ClN<sub>3</sub>•3 HCl•1.2 H<sub>2</sub>O: C, 37.25; H, 5.51; N, 11.85. Found: C, 36.99; H, 5.21; N, 12.13.

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### Example 36

#### 3-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane hydrochloride

The product from Example 37A (1.15 g, 4.6 mmol) in chloroform (10 mL) was treated with  $\alpha$ -chloroethyl chloroformate (1.1 eq.) at 0 °C. The solution was allowed to warm to ambient temperature over 0.5 hours and then heated at reflux for one hour. The mixture was allowed to cool to ambient temperature and concentrated under reduced pressure. The residue was dissolved in methanol (20 mL) and heated at reflux for one hour. The solvent was removed under reduced pressure to provide a solid that was recrystallized from ethanol to provide the title compound (1.03 g, 83% yield). <sup>1</sup>H NMR (CD<sub>3</sub>OD, 300 MHz)  $\delta$  1.72-1.84 (m, 1H), 1.87-2.0 (m, 1H), 2.0-2.36 (m, 4H), 3.5-3.65 (m, 2H), 3.65-3.78 (m, 1H), 3.8-3.9 (br d,  $J=15$  Hz, 1H), 4.22 (br s, 2H), 7.25 (d,  $J=12$  Hz, 1H), 7.38 (dd,  $J=4.5, 12$  Hz, 1H), 7.97 (d,  $J=4.5$  Hz, 1H); MS (DCI/NH<sub>3</sub>)  $m/z$  238 (M+H)<sup>+</sup>, 255 (M+NH<sub>4</sub>)<sup>+</sup>; Anal. Calcd for C<sub>12</sub>H<sub>16</sub>ClN<sub>3</sub>•HCl: C, 52.57; H, 6.25; N, 15.32. Found: C, 52.82; H, 6.33; N, 15.32.

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### Example 37

#### 9-methyl-3-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane 4-methylbenzenesulfonate

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### Example 37A

#### 9-methyl-3-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane

9-Methyl-3,9-diazabicyclo[4.2.1]nonane (prepared as described in U.S. Patent 2,999,091) and 2-chloro-5-iodopyridine were coupled according the procedure of Example 15C to provide the title compound (78% yield). <sup>1</sup>H NMR (free base, CDCl<sub>3</sub>, 300 MHz)  $\delta$  1.23-1.48 (m, 2H), 1.65-1.76 (m, 1H), 1.91-2.27 (m, 3H), 2.44 (s, 3H), 3.18-

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3.35 (m, 3H), 3.48-3.54 (m, 2H), 3.65 (br d, J=13.5 Hz, 1H), 6.98 (dd, J=3, 8.25 Hz, 1H), 7.06 (d, J=8.25 Hz, 1H), 7.87 (d, J=3 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 252 (M+H)<sup>+</sup>, 269 (M+NH<sub>4</sub>)<sup>+</sup>; Anal. Calcd for C<sub>13</sub>H<sub>18</sub>ClN<sub>3</sub>•C<sub>7</sub>H<sub>8</sub>O<sub>3</sub>S: C, 56.66; H, 6.18; N, 9.91. Found: C, 56.76; H, 6.15; N, 9.77.

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### Example 37B

#### 9-methyl-3-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane 4-methylbenzenesulfonate

The product from Example 37A (641 mg), was treated with 10% Pd/C (61.8 mg) in methanol (11 mL) and triethyl amine (0.64 mL) under a hydrogen atmosphere (60 psi) at 50 °C for one hour. The mixture was filtered and concentrated under reduced pressure to provide a solid. The resulting solid was taken up in EtOAc and washed with saturated NaHCO<sub>3</sub> and brine. The organic phase was dried (MgSO<sub>4</sub>) and concentrated under reduced pressure to provide the free base (91 % yield). The free base was treated with 4-methylbenzenesulfonate (1.0 eq) and the obtained solid was recrystallized from ethanol/ethyl acetate. <sup>1</sup>H NMR (CD<sub>3</sub>OD, 300 MHz) δ 1.83-1.93 (m, 1H), 1.93-2.11 (m, 2H), 2.15-2.29 (m, 1H), 2.37 (s, 3H), 2.44-2.56 (m, 2H), 2.95 (s, 3H), 3.61-3.82 (m, 4H), 4.02-4.15 (m, 2H), 7.23 (d, J=7.5 Hz, 2H), 7.29 (dd, J=4.5, 7.5 Hz, 1H), 7.69 (d, J=7.5 Hz, 2H), 7.94 (dd, J=1.5, 4.5 Hz, 1H), 8.2 (d, J=3 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 218 (M+H)<sup>+</sup>, 235 (M+NH<sub>4</sub>)<sup>+</sup>; Anal. Calcd for C<sub>13</sub>H<sub>19</sub>N<sub>3</sub>•C<sub>7</sub>H<sub>8</sub>O<sub>3</sub>S: C, 61.67; H, 6.99; N, 10.79. Found: C, 61.50; H, 7.03; N, 10.76.

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### Example 38

#### (1S,4S)-2-(5-aminocarbonyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane bis(4-methylbenzenesulfonate)

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### Example 38A

#### tert-butyl (1S,4S)-5-(5-aminocarbonyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2- carboxylate

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The product of Example 32A (0.43 g, 1.43 mmol) in ethanol (20 mL) was treated with 30% H<sub>2</sub>O<sub>2</sub> (1.40 mL) and 6N NaOH (1.40 mL) and heated at 50 °C for 2 hours. The

mixture was poured into 15% NaOH (50 mL) and extracted with CH<sub>2</sub>Cl<sub>2</sub> (150 mL). The organic phase was dried (MgSO<sub>4</sub>) and concentrated under reduced pressure. The residue was purified on SiO<sub>2</sub> (5% MeOH/CH<sub>2</sub>Cl<sub>2</sub>) to provide the title compound (0.20 g, 44%) as a white solid. MS (DCI/NH<sub>3</sub>) m/z 319 (M+H)<sup>+</sup>.

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#### Example 38B

##### (1S,4S)-2-(5-aminocarbonyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane bis(4-methylbenzenesulfonate)

The product of Example 38A was processed as described in Example 2B to provide the title compound. <sup>1</sup>H NMR (MeOD, 300 MHz) δ 2.12 (d, J=15.0 Hz, 1H), 2.32 (d, J=15.0 Hz, 1H), 3.42 (s, 2H), 3.79 (dd, J=2.0, 10.0 Hz, 1H), 4.60 (s, 1H), 4.88 (s, 1H), 7.70 (t, J=1.0 Hz, 1H), 8.21 (d, J=3.0 Hz, 1H), 8.42 (d, J=1.0 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 219 (M+H)<sup>+</sup>; Anal. calculated for C<sub>24</sub>H<sub>30</sub>N<sub>4</sub>O<sub>6</sub>S<sub>2</sub>: C, 52.27; H, 5.73; N, 11.55. Found C, 51.92; H, 5.66; N, 10.48.

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#### Example 39

##### (1R,4R)-2-(5-hydroxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane 4-methylbenzenesulfonate

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#### Example 39A

##### tert-butyl (1R,4R)-5-(5-benzyloxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2- carboxylate

The product from Example 15B and 5-(benzyloxy)-3-bromo-pyridine, prepared as described in (US 5,733,912) were coupled according to the procedure described in Example 15C to provide the title compound. MS (DCI/NH<sub>3</sub>) m/z 382 (M+H)<sup>+</sup>.

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#### Example 39B

##### (1R,4R)-2-(5-benzyloxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane

The product from Example 39A (0.52 g, 1.36 mmol) in EtOH (10 mL) was treated with 4N HCl/dioxane (10 mL) and stirred at ambient temperature for 1 hour. The volatiles were removed under reduced pressure and the residue was purified on SiO<sub>2</sub>

30

(10% MeOH/CH<sub>2</sub>Cl<sub>2</sub>/1% NH<sub>4</sub>OH) to provide the title compound (0.347 g, 90% yield) as a white solid. MS (DCI/NH<sub>3</sub>) m/z 282 (M+H)<sup>+</sup>.

#### Example 39C

##### 5        (1R,4R)-2-(5-hydroxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane

The product from Example 39B (0.347 g, 1.23 mmol) in EtOH (10 mL) was treated with 10% Pd/C (10 mg) and stirred at ambient temperature under a hydrogen atmosphere (1 atm) for 16 hours. The catalyst was filtered, washed with EtOH (10 mL) and the combined filtrate was concentrated under reduced pressure. The residue was  
10 purified by chromatography on SiO<sub>2</sub> (10% MeOH/CH<sub>2</sub>Cl<sub>2</sub>/1% NH<sub>4</sub>OH) to provide the free base of the title compound (0.168 g, 71% yield) as a light yellow solid. The free base was dissolved in EtOH and treated with a solution of para-toluenesulfonic acid (0.167g, 1 eq) in a minimum volume of EtOH. The solution was concentrated under reduced pressure to provide the title compound (330 mg, 71% yield) as an off-white  
15 foam. <sup>1</sup>H NMR (MeOD, 300 MHz) δ 2.05(d, J=13.0 Hz, 1H), 2.28 (d, J=13.0 Hz, 1H), 3.32-3.36 (m, 3H), 3.70 (dd, J=3.0,10.0 Hz, 1H), 4.51 (s, 1H), 4.67 (s, 1H), 6.55 (t, J=2.0 Hz, 1H), 7.51 (d, J=2.0 Hz, 1H), 7.53 (d, J=2.0 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 192 (M+H)<sup>+</sup>; Anal. calculated for C<sub>17</sub>H<sub>21</sub>N<sub>3</sub>O<sub>4</sub>S•0.8 H<sub>2</sub>O: C, 54.04; H, 6.03; N, 11.12. Found C, 54.15; H, 6.11; N, 10.83.

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#### Example 40

##### (1R,4R)-2-(6-chloro-5-hydroxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane 4-methylbenzenesulfonate

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#### Example 40A

##### 5-bromo-3-pyridinol

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3-(Benzyloxy)-5-bromopyridine (15.0g, 56.8 mmol), prepared as described in (US 5,733,912), and 30% HBr/HOAc (200 mL) were stirred at ambient temperature for 16 hours. The reaction mixture was diluted with diethyl ether (500 mL) and the resulting  
white solid (12.9 g) was isolated by filtration. The solid, in methanol (300 mL), was  
treated with concentrated NH<sub>4</sub>OH (50 mL). After stirring at ambient temperature for 12



hours, the reaction mixture was concentrated under reduced pressure to provide the title compound (9.8 g, 89%) as a white solid. MS (DCI/NH<sub>3</sub>) m/z 174, 176 (M+H)<sup>+</sup>.

#### Example 40B

5                    5-bromo-2-chloro-3-pyridinol

The product from Example 40A (9.8g, 56.3 mmol) and NaOH (2.40 g, 100 mmol) in water (100mL) were treated with NaOCl (35 ml of 10% solution). The reaction mixture was stirred at ambient temperature for 16 hours and then quenched with acetic acid (5 ml), extracted with ethyl acetate (500mL), dried (MgSO<sub>4</sub>), and  
10 concentrated under reduced pressure. The residue was purified on SiO<sub>2</sub> (3% MeOH/CH<sub>2</sub>Cl<sub>2</sub>) to provide the title compound (11.20 g, 96% yield) as a yellow solid. MS (DCI/NH<sub>3</sub>) m/z 208, 210 (M+H)<sup>+</sup>.

#### Example 40C

15                    5-bromo-2-chloro-3-(methoxymethoxy)pyridine

The product from Example 40B (11.2 g, 53.1 mmol) in diethyl ether (50 mL) was added to a suspension of NaH (1.69 g, 70 mmol) in DMF (300 mL) and diethyl ether (60 mL). The mixture was stirred at ambient temperature for 30 minutes and then treated with a solution of chloromethyl methyl ether (5.65 g, 70 mmol, Aldrich Chemical Co.) in  
20 diethyl ether (30 mL). After stirring at ambient temperature for 2 hours, the mixture was quenched by cautious addition of water (200 mL). The aqueous mixture was extracted with diethyl ether (300 mL), and the organic phase was dried (MgSO<sub>4</sub>) and concentrated under reduced pressure. The residue was purified on SiO<sub>2</sub> (ethyl acetate/hexane (1/4)) to provide the title compound (8.29 g, 61% yield) as a colorless oil. MS (DCI/NH<sub>3</sub>) m/z  
25 252, 254 (M+H)<sup>+</sup>.

#### Example 40D

tert-butyl (1R,4R)-5-(6-chloro-5-methoxymethoxy-3-pyridinyl)-2,5-  
diazabicyclo[2.2.1]heptane-2-carboxylate

The product from Example 15B (1.0 g, 5.0 mmol) in anhydrous toluene (50 mL) was treated with the product from Example 40C (1.27g, 5.0 mmol), Pd<sub>2</sub>(dba)<sub>3</sub> (0.093 g, 0.1 mmol), BINAP (0.126 g, 0.2 mmol) and sodium tert-butoxide (0.83 g, 8.6 mmol). The reaction mixture was heated at 80 °C for 4 hours. The mixture was allowed to cool to ambient temperature, diluted with ether (100 mL), washed with brine (100 mL), dried (MgSO<sub>4</sub>), and concentrated under reduced pressure. The residue was purified by chromatography on SiO<sub>2</sub> (5% MeOH/CH<sub>2</sub>Cl<sub>2</sub>) to provide the title compound (1.0 g, 52% yield) as a yellow oil. MS (DCI/NH<sub>3</sub>) m/z 370 (M+H)<sup>+</sup>.

10

Example 40E(1R,4R)-2-(6-chloro-5-hydroxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

The product from Example 40D (0.60 g, 1.62 mmol) in acetonitrile (8 mL) was treated with Amberlist resin (7.5 g) and shaken at ambient temperature for 48 hours. The resin was removed by filtration and the filtrate was concentrated under reduced pressure. The residue was purified on SiO<sub>2</sub> (10% MeOH/CH<sub>2</sub>Cl<sub>2</sub>/1% NH<sub>4</sub>OH) to provide the free base of the title compound (0.121 g) as a white solid. The free base in EtOH was treated with 4-methylbenzenesulfonic acid (0.102 g, 1 eq.) for 10 minutes. The solvent was removed under reduced pressure to provide the title compound (222 mg, 33% yield) as a white solid: <sup>1</sup>H NMR (MeOD, 300 MHz) δ 2.06 (d, J=12.0 Hz, 1H), 2.37 (d, J=12.0 Hz, 1H), 3.28-3.35 (m, 3H), 3.70 (dd, J=3.0,12.0 Hz, 1H), 4.51 (s, 1H), 4.65 (s, 1H), 6.65 (d, J=3.0 Hz, 1H), 7.35 (d, J=3.0 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 226 (M+H)<sup>+</sup>, 243 (M+NH<sub>4</sub>)<sup>+</sup>; Anal. Calculated for C<sub>17</sub>H<sub>20</sub>N<sub>3</sub>O<sub>4</sub>SCl•0.2 TsOH•0.60 H<sub>2</sub>O: C, 49.87; H, 5.19; N, 9.48. Found C, 49.86; H, 5.36; N, 9.52.

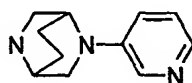
25

Example 413-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane  
bis(4-methylbenzenesulfonate)

The product from Example 36 (1.6 mmol) was hydrogenated according to the procedure of Example 37B to provide the free base (86% yield). This was combined with 4-methylbenzenesulfonate (2.0 eq) and the obtained solid was recrystallized from

30

ethanol/ethyl acetate to provide the title compound.  $^1\text{H}$  NMR ( $\text{CD}_3\text{OD}$ , 300 MHz)  $\delta$  1.73-1.83 (m, 1H), 1.92-2.35 (m, 5H), 2.47 (s, 3H), 3.71-3.82 (m, 3H), 3.94 (br d,  $J=15$  Hz, 1H), 4.27 (br d,  $J=15$  Hz, 2H), 7.23 (d,  $J=7.5$  Hz, 4H), 7.69 (d,  $J=7.5$  Hz, 4H), 7.80 (m, 1H), 8.0-8.09 (m, 2H), 8.48 (d,  $J=3$  Hz, 1H); MS (DCI/ $\text{NH}_3$ )  $m/z$  204 ( $\text{M}+\text{H}$ ) $^+$ , 221 ( $\text{M}+\text{NH}_4$ ) $^+$ ; Anal. Calcd for  $\text{C}_{12}\text{H}_{17}\text{N}_3\cdot\text{C}_{14}\text{H}_{16}\text{O}_6\text{S}_2$ : C, 57.02; H, 6.07; N, 7.67. Found: C, 56.88; H, 6.17; N, 7.57.



#### Example 42

#### 2-(3-pyridinyl)-2.5-diazabicyclo[2.2.2]octane

#### dihydrochloride

#### Example 42A

#### tert-butyl 5-(3-pyridinyl)-2.5-diazabicyclo[2.2.2]octane-2-carboxylate

2-5-Diazabicyclo[2.2.2]octane (390 mg, 3.5 mmole), prepared by the method of Sturm and Henry (J. Med. Chem. (1974), 17, 481), was treated with 3-bromopyridine (545 mg, 3.5 mmole), BINAP (92 mg, 0.14 mmole),  $\text{Pd}_2(\text{dba})_3$  (40 mg, 0.07 mmole) and sodium tert-butoxide (431 mg 4.5 mmole) in toluene (10 mL) under a nitrogen atmosphere. After heating the mixture at  $75^\circ\text{C}$   $\pm 5^\circ\text{C}$  for 2 hours, the mixture was allowed to cool to ambient temperature and treated with di-tert-butyl-dicarbonate (1.5 g, 6.9 mmole) and then allowed to stir an additional 16 hours. The reaction mixture was filtered and concentrated under reduced pressure. The residue was purified by chromatography ( $\text{SiO}_2$ , hexanes:ethyl acetate 9:1 to 1:1) to provide the title compound (193 mg, 19% yield). MS (DCI/ $\text{NH}_3$ )  $m/z$  290 ( $\text{M}+\text{H}$ ) $^+$ , 307 ( $\text{M}+\text{NH}_4$ ) $^+$ .

#### Example 42B

#### 2-(3-pyridinyl)-2.5-diazabicyclo[2.2.2]octane

#### dihydrochloride

The product from Example 42A (137 mg, 0.6 mmole) was treated with a 1:1 mixture of  $\text{CH}_2\text{Cl}_2$  and TFA (3 mL). After two hours, the solvent was removed under reduced pressure and the residue purified by chromatography ( $\text{SiO}_2$ ,  $\text{CHCl}_3$ :MeOH: $\text{NH}_4\text{OH}$  95:5:0 to 95:4.5:0.5) to provide the free base. The free base was

treated with excess 1M HCl in diethyl ether to provide the title compound (65 mg, 37% yield). <sup>1</sup>H NMR (CD<sub>3</sub>OD, 300 MHz) δ 2.04-2.17 (m, 2H), 2.21-2.25 (m, 2H), 3.5-3.69 (m, 3H), 3.90 (d, J=11.63 Hz 1H), 4.00 (br s, 1H), 4.45 (br s, 1H), 7.87 (dd, J=5.01, 8.82 Hz, 1H), 7.94 (dd, J=1.01, 9.16 Hz, 1H), 8.00 (d, J=5.08 Hz, 1H), 8.28 (d, J=1.70 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 190 (M+H)<sup>+</sup>, 207 (M+NH<sub>4</sub>)<sup>+</sup>; Anal. Calculated for C<sub>11</sub>H<sub>13</sub>N<sub>3</sub>•2.1 HCl•0.4 C<sub>4</sub>H<sub>8</sub>O<sub>2</sub>: C, 50.27; H, 6.80; N, 13.96. Found: C, 50.05; H, 7.12; N, 14.34.

#### Example 43

10                    (1S,4S)-2-(5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
                         bis(4-methylbenzenesulfonate)

#### Example 43A

##### 3-bromo-5-methoxypyridine

15                    A suspension of NaH (0.47 g, 19.6 mmol) in DMF (20 mL) was cautiously treated with methanol (0.59 g, 18.4 mmol). After 30 minutes, the mixture was treated with a solution of 3,5-dibromopyridine (4.0 g, 16.9 mmol) in DMF (5.0 mL). After stirring overnight, the reaction mixture was quenched with saturated aqueous NH<sub>4</sub>Cl and extracted with diethyl ether (200 mL). The organic phase was dried (MgSO<sub>4</sub>) and  
20                    concentrated under reduced pressure. The residue was purified by chromatography on SiO<sub>2</sub> (CH<sub>2</sub>Cl<sub>2</sub>) to provide the title compound (2.24 g, 70% yield) as a yellow solid.

#### Example 43B

25                    tert-butyl (1S,4S)-5-(5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-  
                         carboxylate

tert-Butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate, prepared as described in (J. Med. Chem., (1988) 31, 1598-1611), and the product from Example 43A were coupled according to the procedure described in Example 1A to provide the title compound. MS (DCI/NH<sub>3</sub>) m/z 306 (M+H)<sup>+</sup>.

30

#### Example 43C

(1S,4S)-2-(5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
bis(4-methylbenzenesulfonate)

The product from Example 43B was processed as described in Example 2B to provide the title compound. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 1.82-2.01 (m, 2H), 3.02 (d, J=10 Hz, 1H), 3.08 (s, 2H), 3.63 (dd, J=3.0,9.0 Hz, 1H), 3.82 (s, 3H), 3.87 (s, 1H), 4.32 (s, 1H), 6.33 (t, J=2.0 Hz, 1H), 7.64 (d, J=3.0 Hz, 1H), 7.68 (d, J=2.0 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 206 (M+H)<sup>+</sup>; Anal. calculated for C<sub>25</sub>H<sub>31</sub>N<sub>3</sub>O<sub>7</sub>S<sub>2</sub>•0.78 H<sub>2</sub>O: C, 52.89; H, 5.86; N, 7.40. Found C, 52.63; H, 5.91; N, 7.12.

10

Example 44

(1R,4R)-2-(5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

Example 44A

15

tert-butyl (1R,4R)-5-(5-bromo-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-  
carboxylate

The product from Example 15B and 3,5-dibromopyridine were processed as described in Example 1A to provide the title compound.

20

Example 44B

tert-butyl (1R,4R)-5-(5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

The product from Example 44A was processed as described in Example 32A to provide the title compound. MS (DCI/NH<sub>3</sub>) m/z 301 (M+H)<sup>+</sup>.

25

Example 44C

(1R,4R)-2-(5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

The product of Example 44B was processed as described in Example 2B to provide the title compound. <sup>1</sup>H NMR (MeOD, 300 MHz) δ 2.10 (dt, J=1.0, 11.0 Hz, 1H), 2.31 (dt, J=1.0, 11.0 Hz, 1H), 3.38 (d, J=2.0 Hz, 2H), 3.42 (d, J=1.0 Hz, 1H), 3.75 (dd, J=3.0, 9.0 Hz, 1H), 4.56 (s, 1H), 4.82(s, 1H), 7.50 (dd, J=1.0, 4.0 Hz, 1H), 8.23 (d,

J=4.0 Hz, 1H), 8.25 (d, J=3.0 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 201 (M+H)<sup>+</sup>, 218 (M+NH<sub>4</sub>)<sup>+</sup>; Anal. calculated for C<sub>18</sub>H<sub>20</sub>N<sub>4</sub>O<sub>3</sub>S•0.50 H<sub>2</sub>O: C, 56.68; H, 5.55; N, 14.69. Found C, 56.92; H, 5.48; N, 14.29.

5

Example 45

(1S,4S)-2-(6-chloro-5-hydroxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

Example 45A

10

tert-butyl (1S,4S)-5-(6-chloro-5-methoxymethoxy-3-pyridinyl)-2,5-  
diazabicyclo[2.2.1]heptane-2-carboxylate

tert-Butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate, prepared as described in (J. Med. Chem. (1988) 31, 1598-1611), and the product from Example 40C were processed as described in Example 40D to provide the title compound. MS  
15 (DCI/NH<sub>3</sub>) m/z 370 (M+H)<sup>+</sup>.

Example 45B

(1S,4S)-2-(6-chloro-5-hydroxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

20

The product from Example 45A (1.00 g, 2.7 mmol) in EtOH (2.0 mL) was treated with 4N HCl/dioxane (5 mL) and then heated at 60 °C for 4 hours. The reaction mixture was allowed to cool to ambient temperature and then concentrated under reduced pressure. The residue was purified on SiO<sub>2</sub> (10% MeOH/CH<sub>2</sub>Cl<sub>2</sub>/1% NH<sub>4</sub>OH) to provide the free base of the title compound (0.424 g) as a light yellow solid. The free base was  
25 treated with 4-methylbenzenesulfonic acid (0.356 g, 1 eq) in a minimum amount of EtOH for 10 minutes then concentrated under reduced pressure to produce the title compound (0.78 g, 72% yield) as a white solid. <sup>1</sup>H NMR (MeOD, 300 MHz) δ 2.08 (d, J=12.0 Hz, 1H), 2.28 (d, J=12.0 Hz, 1H), 3.32-3.38 (m, 3H), 3.70 (dd, J=3.0,12.0 Hz, 1H), 4.52 (t, J=1.0 Hz, 1H), 4.65 (s, 1H), 6.64 (d, J=3.0 Hz, 1H), 7.32 (d, J=3.0 Hz, 1H);  
30 MS (DCI/NH<sub>3</sub>) m/z 226 (M+H)<sup>+</sup>, 243 (M+NH<sub>4</sub>)<sup>+</sup>; Anal. calculated for C<sub>17</sub>H<sub>20</sub>N<sub>3</sub>ClO<sub>4</sub>S•3.0 H<sub>2</sub>O: C, 45.18; H, 5.80; N, 9.30. Found C, 45.12; H, 5.68; N, 9.29.

Example 46

(1R,4R)-2-(6-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

5

Example 46A

tert-butyl (1R,4R)-5-(6-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-  
carboxylate

The product from Example 15B and 2-methoxy-5-bromopyridine (purchased  
10 from Frontier Scientific) were processed as described in Example 15C to provide the title  
compound. MS (DCI/NH<sub>3</sub>) m/z 306 (M+H)<sup>+</sup>.

Example 46B

(1R,4R)-2-(6-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

15

The product from Example 46A was processed as described in Example 2B to  
provide the title compound. <sup>1</sup>H NMR (MeOD, 300 MHz) δ 2.05 (d, J=11.0 Hz, 1H), 2.28  
(d, J=11.0 Hz, 1H), 3.25 (dd, J=3.0, 12.0 Hz, 1H), 3.35 (s, 2H), 3.72 (dd, J=3.0, 12.0 Hz,  
1H), 3.78(s, 3H), 4.48 (t, J=1.0 Hz, 1H), 4.61 (s, 1H), 6.84 (d, J=11.0 Hz, 1H), 7.28 (dd,  
20 J=3.0, 9.0 Hz, 1H), 7.53 (d, J=3.0 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 206 (M+H)<sup>+</sup>; Anal.  
calculated for C<sub>18</sub>H<sub>23</sub>N<sub>3</sub>O<sub>4</sub>S•0.45.0 H<sub>2</sub>O: C, 56.07; H, 6.25; N,10.90. Found C, 56.14; H,  
6.12; N, 10.52.

Example 47

(1R,4R)-2-(6-chloro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

25

Example 47A

tert-butyl (1R,4R)-5-(6-chloro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-  
carboxylate

30

The product from Example 15B and 2-chloro-5-iodo-3-methylpyridine, prepared as described in (US 5,733,912) were processed as described in Example 15C to provide the title compound. MS (DCI/NH<sub>3</sub>) m/z 324 (M+H)<sup>+</sup>.

5

Example 47B(1R,4R)-2-(6-chloro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

The product from Example 47A was processed as described in Example 2B to provide the title compound. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 1.89 (d, J=10.0 Hz, 1H), 1.98 (d, J=10.0 Hz, 1H), 2.31 (s, 3H), 3.00 (dd, J=1.0, 10.0 Hz, 1H), 3.09 (s, 2H), 3.63 (dd, J=3.0, 9.0 Hz, 1H), 3.88 (s, 1H), 4.29 (s, 1H), 6.72 (d, J=2.0 Hz, 1H), 7.56 (d, J=3.0 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 224 (M+H)<sup>+</sup>; Anal. calculated for C<sub>18</sub>H<sub>22</sub>N<sub>3</sub>O<sub>3</sub>SCI•0.2 H<sub>2</sub>O: C, 54.12; H, 5.65; N, 10.52. Found C, 54.21; H, 5.80; N, 10.18.

15

Example 48(1R,4R)-2-(5,6-dichloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonateExample 48A

20 tert-butyl (1R,4R)-5-(5,6-dichloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-  
carboxylate

The product from Example 15B and 2,3-dichloro-5-iodopyridine, prepared as described in (US 5,733,912) were processed as described in Example 15C to provide the title compound. MS (DCI/NH<sub>3</sub>) m/z 344 (M+H)<sup>+</sup>.

25

Example 48B(1R,4R)-2-(5,6-dichloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

30 The product from Example 48A was processed as described in Example 2B to provide the title compound. <sup>1</sup>H NMR (MeOD, 300 MHz) δ 2.07 (m, 1H), 2.30 (m, 1H), 3.28-3.34 (m, 1H), 3.47 (s, 2H), 3.72 (dd, J=2.0, 10.0 Hz, 1H), 4.53 (t, J=1.0 Hz, 1H),



4.75 (s, 1H), 7.36 (d, J=3.0 Hz, 1H), 7.77 (d, J=3.0 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 244 (M+H)<sup>+</sup>; Anal. calculated for C<sub>17</sub>H<sub>19</sub>N<sub>3</sub>O<sub>3</sub>SCl<sub>2</sub>•0.05 EtOH: C, 49.06; H, 4.65; N, 10.04. Found C, 49.22; H, 5.04; N, 11.05.

5

Example 49

6-(6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane  
bis(4-methylbenzenesulfonate)

Example 49A

10

tert-butyl 2,6-diazabicyclo[3.2.1]octane-2-carboxylate

The product from Example 35B (140 mg, 0.568 mmol) in CH<sub>2</sub>Cl<sub>2</sub> at ambient temperature was treated with triethylamine followed by di-tert-butyl dicarbonate. The solution was stirred for 2 hours, diluted with saturated aqueous K<sub>2</sub>CO<sub>3</sub>, and extracted with CH<sub>2</sub>Cl<sub>2</sub> (2X). The organic extracts were combined, dried (Na<sub>2</sub>SO<sub>4</sub>), and concentrated under reduced pressure to provide 190 mg a colorless oil. A suspension of the oil and 10% Pd/C (20 mg) in MeOH (10 mL) were stirred under one atmosphere of hydrogen (balloon) for 6 hours. The catalyst was removed by filtration through a plug of Celite (CH<sub>2</sub>Cl<sub>2</sub> wash). The filtrate was concentrated to provide (106 mg, 91%) the title compound as a colorless oil. MS (DCI/NH<sub>3</sub>) m/z 213 (M+H)<sup>+</sup>, 230 M+NH<sub>4</sub><sup>+</sup>.

20

Example 49B

tert-butyl 6-(6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane-2-carboxylate

The product from Example 49A and 2-chloro-5-iodopyridine were processed as described in Example 1A to provide the title compound (30% yield) as a light yellow oil. MS (DCI/NH<sub>3</sub>) m/z 324, 326 (M+H)<sup>+</sup>.

25

Example 49C

6-(6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane  
bis(4-methylbenzenesulfonate)

The product from Example 49B (40 mg, 0.12 mmol) in EtOAc (3 mL) was treated with p-toluenesulfonic acid•monohydrate (59 mg, 0.31 mmol). The solution was refluxed for 2 hours and allowed to cool to ambient temperature resulting in formation of

30

a precipitate. The precipitate was triturated with diethyl ether (2X) and placed under high vacuum to provide 70 mg (85%) of the title compound as a white solid. <sup>1</sup>H NMR (D<sub>2</sub>O) δ 1.92 (m, 1H), 2.14-2.28 (m, 3H), 2.99 (s, 6H), 2.99 (dt, J=5.5, 12.9 Hz, 1H), 3.31 (dd, J=6.6, 13.4 Hz, 1H), 3.56 (d, J=12.1 Hz, 1H), 3.77 (dd, J=4.4, 12.1 Hz, 1H), 4.38 (m, 2H), 7.25 (dd, J=3.2, 9.0 Hz, 1H), 7.36 (d, J=8.5 Hz, 4H), 7.40 (d, J=9.2 Hz, 1H), 7.68 (d, J=8.5 Hz, 4H), 7.78 (d, J=2.9 Hz, 1H); MS (CI/NH<sub>3</sub>) m/z 224, 226 (M+H)<sup>+</sup>; Anal. Calcd for C<sub>11</sub>H<sub>14</sub>ClN<sub>3</sub>•2.5C<sub>7</sub>H<sub>8</sub>O<sub>3</sub>S•0.5 H<sub>2</sub>O: C, 51.61; H, 5.32; N, 6.34. Found: C, 51.31; H, 5.43; N, 6.21.

10

Example 50

(1R,4R)-2-(5-aminocarbonyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
bis(4-methylbenzenesulfonate)

Example 50A

15 tert-butyl (1R,4R)-5-(5-aminocarbonyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-  
carboxylate

The product from Example 44A was processed according to the procedure described in Example 38A to provide the title compound. MS (DCI/NH<sub>3</sub>) m/z 319 (M+H)<sup>+</sup>.

20

Example 50B

(1R,4R)-2-(5-aminocarbonyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
bis(4-methylbenzenesulfonate)

The product from Example 50A was processed as described in Example 2B to provide the title compound. <sup>1</sup>H NMR (MeOD, 300 MHz) δ 2.26 (d, J=12.0 Hz, 1H), 2.25 (d, J=12.0 Hz, 1H), 3.41-3.52 (m, 3H), 3.82 (dd, J=2.0, 10.0 Hz, 1H), 4.65 (t, J=1.0 Hz, 1H), 5.96 (s, 1H), 8.14 (dd, J=1.0, 3.0 Hz, 1H), 8.32 (d, J=2.0 Hz, 1H), 8.47 (d, J=1.0 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 219 (M+H)<sup>+</sup>; Anal. calculated for C<sub>24</sub>H<sub>30</sub>N<sub>4</sub>O<sub>7</sub>S<sub>2</sub>•0.40 TsOH•1.0 H<sub>2</sub>O: C, 50.49; H, 5.57; N, 8.79. Found C, 50.53; H, 5.75; N, 8.76.

30

Example 51

(1R,4R)-2-(6-chloro-5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

Example 51A

5                    5-bromo-2-chloro-3-methoxypyridine

The product from Example 40B (1.2 g, 5.8 mmol) in diethyl ether (5 mL) was added to a suspension of NaH (181 mg, 7.5 mmol) in dry DMF (30 mL) and diethyl ether (6 mL). After stirring at ambient temperature for 30 minutes, the mixture was treated with a solution of iodomethane (1.06 g, 7.5 mmol) in diethyl ether (3 mL) and stirring  
10 was continued for an additional 30 minutes. The reaction mixture was quenched with water (20 mL), extracted with diethyl ether (100 mL), dried (MgSO<sub>4</sub>), and concentrated under reduced pressure. The residue was purified on SiO<sub>2</sub> (ethyl acetate/hexane, 1/4) to provide the title compound (0.32 g, 25%) as a colorless oil. MS(DCI/NH<sub>3</sub>) m/z 222/224/226 (M+H)<sup>+</sup>.

15

Example 51B

tert-butyl (1R,4R)-5-(6-chloro-5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane-2-  
carboxylate

The product from Example 15B and the product from Example 51A were  
20 processed as described in Example 15C to provide the title compound (74 % yield). MS(DCI/NH<sub>3</sub>) m/z 340 (M+H)<sup>+</sup>.

Example 51C

(1R,4R)-2-(6-chloro-5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane  
25                    4-methylbenzenesulfonate

The product from Example 51B was processed as described in Example 2B to provide the title compound (50 % yield). <sup>1</sup>H NMR (MeOD, 300 MHz) δ 1.82 (d, J=12.0 Hz, 1H), 1.96 (d, J=12.0 Hz, 1H), 2.97 (s, 3H), 3.58 (dd, J=3.0, 12.0 Hz, 1H), 3.78-3.82 (m, 2H), 3.89 (s, 1H), 4.46 (s, 1H), 4.79 (s, 1H), 6.68 (d, J=2.0 Hz, 1H), 7.28 (d, J=2.0  
30 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 240 (M+H)<sup>+</sup>; Anal. calculated for C<sub>18</sub>H<sub>22</sub>N<sub>3</sub>O<sub>4</sub>SCl•0.25 TsOH•0.60 H<sub>2</sub>O: C, 50.93; H, 5.45; N, 9.02. Found C, 50.94; H, 5.57; N, 8.95.

Example 52

(1S,4S)-2-(5-pyrimidinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

5

Example 52A

tert-butyl (1S,4S)-5-(5-pyrimidinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

tert-Butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate (330 mg, 1.6 mmol), prepared as described in (J. Med. Chem., (1988) 31, 1598-1611), and 5-bromopyrimidine (purchased from Acros Scientific) were processed as described in Example 15C to provide the title compound (99 % yield). MS(DCI/NH<sub>3</sub>) m/z 277 (M+H)<sup>+</sup>.

Example 52B

15 (1S,4S)-2-(5-pyrimidinyl)-2,5-diazabicyclo[2.2.1]heptane  
4-methylbenzenesulfonate

The product from Example 52B was processed as described in Example 2B to provide the title compound (33 % yield). <sup>1</sup>H NMR (MeOD, 300 MHz) δ 1.87-2.01 (m, 2H), 3.01-3.16 (m, 3H), 3.67 (dd, J=2.0, 8.0 Hz, 1H), 3.79 (s, 1H), 4.37 (s, 1H), 8.06 (s, 2H), 8.57 (s, 1H); MS (DCI/NH<sub>3</sub>) m/z 177 (M+H)<sup>+</sup>; Anal. calculated for C<sub>16</sub>H<sub>20</sub>N<sub>4</sub>O<sub>3</sub>S•0.10 TsOH•0.25 H<sub>2</sub>O: C, 54.19; H, 5.80; N, 15.14. Found C, 54.24; H, 5.89; N, 15.17.

Example 53

25 (1S,4S)-2-(3-quinolinyl)-2,5-diazabicyclo[2.2.1]heptane  
acetate

Example 53A

tert-butyl (1S,4S)-5-(3-quinolinyl)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate

30 tert-Butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate, prepared as described in (J. Med. Chem., (1988) 31, 1598-1611), and 3-bromoquinoline (purchased

from the Aldrich Chemical Co.) were coupled according to the procedure described in Example 1A to provide the title compound.

### Example 53B

5 (1S,4S)-2-(3-quinolinyl)-2,5-diazabicyclo[2.2.1]heptane  
acetate

The product from Example 53A was processed as described in Example 34B to provide the crude hydrochloride. The crude hydrochloride was purified by preparative HPLC (Waters Nova-Pak HR C18 6  $\mu$ m 60Å 25x100 mm, 0-95% CH<sub>3</sub>CN/10 mM NH<sub>4</sub>OAc over 10 minutes at 40 mL/minute) to provide the title compound after removal of solvents under reduced pressure. <sup>1</sup>H NMR (MeOD, 300 MHz)  $\delta$  1.90 (s, 3H), 2.06 (br d, J=11 Hz, 1H), 2.24 (br d, J=11 Hz, 1H), 3.30, (br s, 2H), 3.41 (d, J=10 Hz, 1H), 3.84 (d, J=10 Hz, 1H), 4.33 (br s, 1H), 4.80 (br s, 1H), 7.34 (m, 1H), 7.46 (m, 2H), 7.73 (br d, J=7 Hz, 1H), 7.87 (br d, J=7 Hz, 1H), 8.51 (br d, J=3 Hz, 1H).

### Example 54

(1S,4S)-2-(3-methyl-5-isothiazolyl)-2,5-diazabicyclo[2.2.1]heptane  
acetate

### Example 54A

tert-butyl (1S,4S)-5-(3-methyl-5-isothiazolyl)-2,5-diazabicyclo[2.2.1]heptane-2-  
carboxylate

tert-Butyl (1S,4S)-2,5-diazabicyclo[2.2.1]heptane-2-carboxylate, prepared as described in (J. Med. Chem., (1988) 31, 1598-1611) and 5-bromo-3-methylisothiazole, prepared as described in (US 3,840,665) were coupled according to the procedure described in Example 1A to provide the title compound.

### Example 54B

30 (1S,4S)-2-(3-methyl-5-isothiazolyl)-2,5-diazabicyclo[2.2.1]heptane  
acetate

The product from Example 54A was processed as described in Example 53B to provide the title compound. <sup>1</sup>H NMR (MeOD, 300 MHz) δ 1.84(s, 3H), 1.86 (m, 1H), 2.04 (br d, J=11 Hz, 1H), 2.18 (s, 3H), 3.06 (m, 2H), 3.16 (br d, J=10 Hz, 1H), 3.30 (m, 1H), 4.05 (br s, 1H), 4.17 (br s, 1H), 5.99 (s, 1H).

5

Example 55

(1R,4R)-2-(thieno[3,2-b]pyridin-2-yl)-2,5-diazabicyclo[2.2.1]heptane  
acetate

10

Example 55A

tert-butyl (1R,4R)-5-(thieno[3,2-b]pyridin-2-yl)-2,5-diazabicyclo[2.2.1]heptane-2-  
carboxylate

The product from Example 15B and 2-bromothieno[3,2-b]pyridine, prepared as described in (J. Het. Chem. (1984), 785-789), were processed as described in Example 1A to provide the title compound.

15

Example 55B

(1R,4R)-2-(thieno[3,2-b]pyridin-2-yl)-2,5-diazabicyclo[2.2.1]heptane  
acetate

20

The product from Example 55A was processed as described in Example 53B to provide the title compound. <sup>1</sup>H NMR (MeOD, 300 MHz) δ 1.92 (s, 3H), 2.04 (br d, J=11 Hz, 1H), 2.26 (br d, J=11 Hz, 1H), 3.28 (m, 1H), 3.41 (m, 2H), 3.74 (dd, J=10, 2 Hz, 1H), 4.33 (br s, 1H), 4.53 (br s, 1H), 6.18 (s, 1H), 7.01 (dd, J=8, 4 Hz, 1H), 8.01 (br d, J=8 Hz, 1H), 8.29 (br d, J=4 Hz, 1H).

25

Example 56

9-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane  
fumarate

30

Example 56A

tert-butyl 9-methyl-3,9-diazabicyclo[4.2.1]nonane-3-carboxylate

9-Methyl-3,9-diazabicyclo[4.2.1]nonane (4.60 g, 33 mmol), prepared as described in (US 2,999,091), in  $\text{CHCl}_3$  (50 mL) at 0 °C, was treated with triethyl amine (6.7 g, 66 mmol) and di-*t*-butyl dicarbonate (14.4 g, 66 mmol). The mixture was allowed to warm to ambient temperature and stir for 12 hours. The reaction mixture was washed in succession with saturated  $\text{NaHCO}_3$  and brine. The organic phase was dried ( $\text{MgSO}_4$ ) and concentrated under reduced pressure to provide the title compound (99% yield). MS ( $\text{DCI}/\text{NH}_3$ )  $m/z$  241 ( $\text{M}+\text{H}$ )<sup>+</sup>.

#### Example 56B

*t*-butyl 3,9-diazabicyclo[4.2.1]nonane-3-carboxylate

The product of Example 56A was processed (on 33 mmol scale) according to the procedure of Example 36 to provide the title compound (51% yield). MS ( $\text{DCI}/\text{NH}_3$ )  $m/z$  227 ( $\text{M}+\text{H}$ )<sup>+</sup>, 241 ( $\text{M}+\text{NH}_4$ )<sup>+</sup>.

#### Example 56C

*t*-butyl 9-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane-3-carboxylate

The product of Example 56B (17 mmol) and 2-chloro-5-iodopyridine (21 mmol) were coupled according the procedure of Example 15C to provide the title compound (21% yield). MS ( $\text{DCI}/\text{NH}_3$ )  $m/z$  338 ( $\text{M}+\text{H}$ )<sup>+</sup>, 355 ( $\text{M}+\text{NH}_4$ )<sup>+</sup>.

#### Example 56D

9-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane

fumarate

The product of Example 56C was treated with trifluoroacetic acid according to the procedure of Example 15D. After purification by chromatography ( $\text{SiO}_2$ ; 10%  $\text{MeOH}$ :89%  $\text{CH}_2\text{Cl}_2$ :1%  $\text{NH}_4\text{OH}$ ), the free base was combined with fumaric acid (1.1 eq.) in hot  $\text{EtOAc}$ . Upon cooling, the title compound separated as a solid in 97% yield. <sup>1</sup>H NMR ( $\text{CD}_3\text{OD}$ , 300 MHz)  $\delta$  1.84-2.08 (m, 3H), 2.22-2.56 (m, 3H), 2.92-3.02 (m, 1H), 3.16-3.29 (m, 2H), 3.58 (d,  $J=4.5$ , 13.5 Hz, 1H), 4.47-4.55 (m, 1H), 4.57-4.66 (m, 1H), 6.67 (s, 2H), 7.25 (s, 2H), 7.86 (s, 1H); MS ( $\text{DCI}/\text{NH}_3$ )  $m/z$  238 ( $\text{M}+\text{H}$ )<sup>+</sup>, 255 ( $\text{M}+\text{NH}_4$ )<sup>+</sup>;

Anal. Calcd for  $C_{12}H_{16}ClN_3 \cdot C_4H_4O_4$ : C, 54.32; H, 5.70; N, 11.88. Found: C, 54.33; H, 5.77; N, 11.77.

#### Example 57

5                    3-(3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane  
                         bis(4-methylbenzenesulfonate)

#### Example 57A

3-(3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane  
10                3,7-Diazabicyclo[3.3.1]nonane, prepared as described in (Garrison, G.L. et. al., J. Org. Chem. 58, 27, (1993) 7670), and 3-bromopyridine were processed as described in Example 1A. The proportions of reagents were changed from Example 1A to the following:  $Pd_2(dba)_3$  (0.02 eq), BINAP (0.05 eq), and NaOt-Bu (1.7 eq). The title compound was obtained in 25% yield after purification by flash chromatography (silica  
15 gel;  $CHCl_3$ :MeOH: $NH_4OH$ ; 90:5:1). MS (DCI/ $NH_3$ ) m/z 204 (M+H)<sup>+</sup>.

#### Example 57B

3-(3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane  
                         bis(4-methylbenzenesulfonate)

20                The product from Example 57A was treated with p-toluenesulfonic acid (2.0 eq) and the obtained solid recrystallized from ethanol/ether to provide the title compound (53% yield). <sup>1</sup>H NMR ( $CD_3OD$ , 300MHz)  $\delta$  2.04 (m, 2H), 2.37 (s, 6H), 2.39 (m, 2H), 3.23 (m, 2H), 3.31 (m, 2H), 3.59 (bd, J=13.24 Hz, 2H), 4.04 (bd, 12.14 Hz, 2H), 7.23 (d, J=8.09 Hz, 4H), 7.67(d, J=8.09 Hz, 4H), 7.88 (dd, J=5.52, 8.83 Hz, 1H), 8.20-8.24(m,  
25 2H), 8.50 (d, J=2.57 Hz, 1H); MS (DCI/ $NH_3$ ) m/z 204 (M+H)<sup>+</sup>; Anal. calculated for  $C_{12}H_{17}N_3 \cdot 2.2 TsOH \cdot H_2O$  C, 56.01; H, 6.04; N, 7.15. Found C, 56.25; H, 6.10; N, 6.79.

#### Example 58

3-(6-Chloro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane  
30                    4-methylbenzenesulfonate



Example 58A3-(6-Chloro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane

3,7-Diazabicyclo[3.3.1]nonane, prepared as described in (Garrison, G.L. et. al., J. Org. Chem. 58, 27, (1993) 7670), and 2-chloro-5-iodopyridine were processed as described in Example 57A. The crude was purified by flash chromatography (silica gel; 5  $\text{CHCl}_3$ :MeOH:NH<sub>4</sub>OH; 90:5:1) to provide the title compound (10% yield). MS (DCI/NH<sub>3</sub>) m/z 238 (M+H)<sup>+</sup>.

Example 58B3-(6-Chloro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane4-methylbenzenesulfonate

The product of Example 58A was treated with p-toluenesulfonic acid (1.0 eq) and the obtained solid recrystallized from ethanol/ether to provide the title compound (53% yield) <sup>1</sup>H NMR (CD<sub>3</sub>OD, 300 MHz)  $\delta$  2.00 (m, 2H), 2.31 (bs, 2H), 2.37 (s, 3H), 3.10 (m, 15 2H), 3.35 (m, 2H), 3.57 (bd, J=13.22 Hz, 2H), 3.85 (bd, 11.19 Hz, 2H), 7.23 (d, J=8.14 Hz, 2H), 7.34 (d, J=8.13 Hz, 1H), 7.57 (dd, J=3.05, 8.81 Hz, 1H), 7.70 (d, J = 8.13 Hz, 2H), 8.15 (d, J=3.39 Hz, 1H); MS (DCI/NH<sub>3</sub>) m/z 238 (M+H)<sup>+</sup>; Anal. calculated for C<sub>12</sub>H<sub>16</sub>ClN<sub>3</sub>•1.1 TsOH•0.5 H<sub>2</sub>O C, 54.25; H, 5.96; N, 9.63. Found C, 54.05; H, 5.60; N, 9.61.

Example 596-(3-pyridinyl)-3,6-diazabicyclo[3.2.1]octaneExample 59A2-[(2-nitrophenyl)sulfonyl]-2-azabicyclo[2.2.1]hept-5-ene

2-Azabicyclo[2.2.1]hept-5-ene (52.5 g, 54 mmole), prepared as described in (J Am Chem. Soc., (1985) 107, 1768), 2-nitrobenzenesulfonyl chloride (119.6 g, 54 mmole), and triethylamine (75 mL, 0.54 mmole) were combined in methylene chloride (500 mL) under a nitrogen atmosphere and stirred for 16 hours. The reaction mixture was quenched with water (500 mL) and the phases separated. The organic phase was washed 30 with 2M HCl (5 x 100 mL), dried (MgSO<sub>4</sub>), and concentrated under reduced pressure.

The residue was purified by chromatography on silica gel (chloroform then hexane:EtOAc 95:5 to 8:2) to provide the title compound (23 g, 23% yield). MS (DCI/NH<sub>3</sub>) m/e 281 (M+H)<sup>+</sup>, 298 (M+NH<sub>4</sub>)<sup>+</sup>.

5

### Example 59B

#### 3-benzyl-6-[(2-nitrophenyl)sulfonyl]-3,6-diazabicyclo[3.2.1]octane

Ozone (O<sub>3</sub>/O<sub>2</sub>) was bubbled through a solution of the product from Example 59A (5.6 g, 2 mmol) in methanol (100 mL) at -78 °C. After one hour, a stream of oxygen was bubbled through the reaction mixture to remove excess ozone. The mixture was treated with dimethyl sulfide (2 mL) and the reaction mixture was allowed to warm to ambient temperature. After 30 minutes, benzylamine hydrochloride (25 g, 170 mmol) and 3A molecular sieves (30g) were added. After 2 hours, NaBH<sub>3</sub>CN (6.3 g, 10 mmol) was added and the reaction mixture stirred for an additional 16 hours. The solids were removed by filtration, and the filtrate was concentrated under reduced pressure. The residue was diluted with water (150 mL), acidified with 6N HCl (200 mL), and allowed to stir for 16 hours. Solid NaOH was added to bring the mixture to pH ~13. The mixture was extracted with EtOAc (5x 200 mL). The extracts were combined, dried (K<sub>2</sub>CO<sub>3</sub>), and concentrated. The residue was purified by chromatography on silica gel (CHCl<sub>3</sub>:MeOH 100:0 to 95:5) to provide the title compound (2.0 g, 28% yield). MS (DCI/NH<sub>3</sub>) m/e 288 (M+H)<sup>+</sup>.

20

### Example 59C

#### 3-benzyl-3,6-diazabicyclo[3.2.1]octane

The product of Example 59B (1.98g, 5 mmole) in DMF (5 mL) was treated with mercaptoacetic acid (0.7 ml, 10 mmole) and lithium hydroxide (0.48g, 20 mmole). After stirring under a nitrogen atmosphere for 2 hours, the reaction mixture was poured into saturated Na<sub>2</sub>CO<sub>3</sub> (20 mL) and extracted with EtOAc (5 x 20mL). The organic extracts were combined, dried (K<sub>2</sub>CO<sub>3</sub>), and concentrated under reduced pressure. The residue was purified on silica gel (CHCl<sub>3</sub>:MeOH:NH<sub>4</sub>OH 95:5:0 to 9:1:0.1) to provide the title compound (450 mg, 45% yield). MS (DCI/NH<sub>3</sub>) m/e 203 (M+H)<sup>+</sup>.

30

Example 59D3-benzyl-6-(3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane

The product of Example 59C (290 mg, 1.4 mmole) and 3-bromopyridine (340 mg, 2.15 mmole) were coupled using the procedure of Example 1A to provide the title compound (306 mg, 90% yield). MS (DCI/NH<sub>3</sub>) m/e 280 (M+H)<sup>+</sup>.

Example 59E6-(3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane

The product from Example 59D (290 mg, 1.1 mmole), in ethanol (2.9 mL) was treated with 20% Pd(OH)<sub>2</sub>/C (117 mg) under a hydrogen atmosphere (60 psi) for 36 hours. The reaction mixture was filtered and the solvent removed under reduced pressure. The residue was purified by chromatography (SiO<sub>2</sub>, CHCl<sub>3</sub>:MeOH:NH<sub>4</sub>OH, 9:1:0 to 9:1:0.1) to provide the title compound (42 mg, 21% yield). <sup>1</sup>H NMR (CD<sub>3</sub>OD, 300 MHz) δ 2.17 (br s, 1H), 2.91 (br s, 1H), 3.40-3.70 (m, 8H) 4.51 (m, 1H), 7.84-7.85 (m, 2H), 8.09 (m, 1H), 8.19 (br s, 1H); MS (DCI/NH<sub>3</sub>) m/e 190 (M+H)<sup>+</sup>.

Example 603-(3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane  
bis(4-methylbenzenesulfonate)

20

Example 60At-butyl 3-benzyl-3,6-diazabicyclo[3.2.1]octane-6-carboxylate

The product of Example 59C can be treated with di-t-butyl dicarbonate (1.1 eq.) in methylene chloride for 4 hours. The solvent is removed under reduced pressure and the residue purified by chromatography to provide the title compound.

25

Example 60Bt-butyl 3,6-diazabicyclo[3.2.1]octane-6-carboxylate

The product from Example 60A can be processed according to the procedure of Example 59E to provide the title compound.

30

Example 60C3-(3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane  
bis(4-methylbenzenesulfonate)

The product from Example 60B can be processed according to the procedure of  
5 Example 2B to provide the title compound.

In Vitro DataDetermination of Nicotinic Acetylcholine Receptor Binding Potencies

Compounds of the invention were subjected to in vitro assays against the  
10 nicotinic acetylcholine receptor as described below and were found to be effective  
binders to the receptor. The In Vitro protocols for determination of nicotinic  
acetylcholine channel receptor binding potencies of ligands were determined as follows.

Binding of [<sup>3</sup>H]-cytisine ([<sup>3</sup>H]-CYT) to neuronal nicotinic acetylcholine receptors  
was accomplished using crude synaptic membrane preparations from whole rat brain  
15 (Pabreza et al., Molecular Pharmacol., 1990, 39:9). Washed membranes were stored at -  
80 °C prior to use. Frozen aliquots were slowly thawed and resuspended in 20 volumes  
of buffer (containing: 120 mM NaCl, 5 mM KCl, 2 mM MgCl<sub>2</sub>, 2 mM CaCl<sub>2</sub> and 50 mM  
Tris-Cl, pH 7.4 @4 °C). After centrifuging at 20,000x g for 15 minutes, the pellets were  
resuspended in 30 volumes of buffer.

20 The test compounds were dissolved in water to make 10 mM stock solutions.  
Each solution was then diluted (1:100) with buffer (as above) and further taken through  
seven serial log dilutions to produce test solutions from 10<sup>-5</sup> to 10<sup>-11</sup> M.

Homogenate (containing 125-150 µg protein) was added to triplicate tubes  
containing the range of concentrations of test compound described above and [<sup>3</sup>H]-CYT  
25 (1.25 nM) in a final volume of 500 µL. Samples were incubated for 60 minutes at 4 °C,  
then rapidly filtered through Whatman GF/B filters presoaked in 0.5% polyethyleneimine  
using 3 x 4 mL of ice-cold buffer. The filters are counted in 4 mL of Ecolume® (ICN).  
Nonspecific binding was determined in the presence of 10 µM (-)-nicotine and values  
were expressed as a percentage of total binding. IC<sub>50</sub> values were determined with the  
30 RS-1 (BBN) nonlinear least squares curve-fitting program and IC<sub>50</sub> values were  
converted to K<sub>i</sub> values using the Cheng and Prusoff correction ( $K_i = IC_{50} / (1 + [ligand] / K_d)$ )

of ligand).

The results are detailed in Table 1. Each Example Number corresponds to the synthetic Examples described above. Examples 1-17 and 20-59 are compounds of the present invention. Examples 18 and 19 are comparative. Example 18 is the 6-chloro-2-pyridinyl [2.2.1]derivative, corresponding to Example 1, the 6-chloro-3-pyridinyl derivative; and Example 19 is the 6-chloro-2-pyridinyl[3.2.1] derivative, corresponding to Example 12, the 6-chloro-3-pyridinyl[3.2.1]derivative. As a lower  $K_i$  value is more desirable, the binding data suggest that the 3-pyridinyl derivative compounds of the present invention have higher affinity for the neuronal nicotinic acetylcholine receptor than 2-pyridinyl derivative compounds.

Table 1  
Binding Data

Example Number	Average $K_i$ (nM)
1	0.041
2	6.0
3	20
4	3.8
5	65
6	22
7	1900
8	2600
9	>10,000
10	37
11	37
12	93
13	0.41
14	11

15	0.01
16	24
17	0.063
18	400
19	>10,000
20	52
21	0.33
22	4.1
23	1.6
24	0.012
25	0.40
27	0.05
28	109
29	37
30	0.17
31	1.2
32	1.6
33	0.03
34	140
35	1.5
36	0.06
37	0.55
38	24
39	0.04
40	0.17
41	0.03

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42	0.02
43	0.57
44	0.03
45	1.6
46	0.25
47	0.009
48	0.01
49	2.7
50	0.83
51	0.10
52	1.0
53	17
54	5.0
55	0.84
56	0.21
57	0.02
58	0.02
59	2.2

#### In Vivo Data

##### Determination of Effectiveness of Nicotinic Acetylcholine Receptor Ligands as Analgesic Agents in the Mouse Hot Plate Paradigm

5        An in vivo protocol was utilized to determine the effectiveness of nicotinic  
acetylcholine receptor ligands as analgesic agents in the mouse hot plate paradigm.

Separate groups of mice, (n=8/group) were utilized for each dose group. All  
drugs were administered by the intraperitoneal route of administration. Test drugs were  
dissolved in water to make a 6.2 mM stock solution. Animals were dosed with this  
10    solution (10 mL/kg body weight) for a 62 micromol/kg dose. Lower doses were

administered similarly, following serial dilution of the stock solution in half-log increments. Animals were dosed 30 minutes prior to testing in the hot plate. The hot-plate utilized was an automated analgesia monitor (Model #AHP16AN, Omnitech Electronics, Inc. of Columbus, Ohio). The temperature of the hot plate was maintained at 55 °C and a cut-off time of 180 seconds was utilized. Latency until the tenth jump was recorded as the dependent measure. An increase in the tenth jump latency relative to the control was considered an effect.

Table 2 shows the minimally effective dose (MED), among the doses tested, at which a significant effect, as defined above, was observed for the present compounds. The data shows that selected compounds of the invention show a significant antinociceptive effect at doses ranging from 0.62 to 62  $\mu\text{mol/kg}$ .

Table 2  
Mouse Hot Plate Data

Example Number	(MED) $\mu\text{mol/kg}$
1	6.2
4	62
15	0.62
16	6.2
20	62
22	19
23	62
24	6.2
25	19
27	1.9
30	1.9
31	62
33	0.19
35	19
36	1.9



37	6.2
38	19
39	62
40	19
41	6.2
44	0.62
46	6.2
47	6.2
48	6.2
57	1.9
58	0.62

Dosage forms for topical administration of a compound of this invention include powders, sprays, ointments and inhalants. The active compound is mixed under sterile conditions with a pharmaceutically acceptable carrier and any needed preservatives,  
5 buffers or propellants which can be required. Ophthalmic formulations, eye ointments, powders and solutions are also contemplated as being within the scope of this invention.

Actual dosage levels of active ingredients in the pharmaceutical compositions of this invention can be varied so as to obtain an amount of the active compound(s) which is effective to achieve the desired therapeutic response for a particular patient, compositions  
10 and mode of administration. The selected dosage level will depend upon the activity of the particular compound, the route of administration, the severity of the condition being treated and the condition and prior medical history of the patient being treated. However, it is within the skill of the art to start doses of the compound at levels lower than required for to achieve the desired therapeutic effect and to gradually increase the dosage until the  
15 desired effect is achieved.

When used in the above or other treatments, a therapeutically effective amount of one of the compounds of the present invention can be employed in pure form or, where such forms exist, in pharmaceutically acceptable salt, ester or prodrug form. Alternatively, the compound can be administered as a pharmaceutical composition

containing the compound of interest in combination with one or more pharmaceutically acceptable excipients. The phrase "therapeutically effective amount" of the compound of the invention means a sufficient amount of the compound to treat disorders, at a reasonable benefit/risk ratio applicable to any medical treatment. It will be understood, however, that the total daily usage of the compounds and compositions of the present invention will be decided by the attending physician within the scope of sound medical judgement. The specific therapeutically effective dose level for any particular patient will depend upon a variety of factors including the disorder being treated and the severity of the disorder; activity of the specific compound employed; the specific composition employed; the age, body weight, general health, sex and diet of the patient; the time of administration, route of administration, and rate of excretion of the specific compound employed; the duration of the treatment; drugs used in combination or coincidental with the specific compound employed; and like factors well known in the medical arts. For example, it is well within the skill of the art to start doses of the compound at levels lower than required to achieve the desired therapeutic effect and to gradually increase the dosage until the desired effect is achieved.

The total daily dose of the compounds of this invention administered to a human or lower animal may range from about 0.001 to about 1000 mg/kg/day. For purposes of oral administration, more preferable doses can be in the range of from about 0.001 to about 5 mg/kg/day. If desired, the effective daily dose can be divided into multiple doses for purposes of administration; consequently, single dose compositions may contain such amounts or submultiples thereof to make up the daily dose.

The present invention also provides pharmaceutical compositions that comprise compounds of the present invention formulated together with one or more non-toxic pharmaceutically acceptable carriers. The pharmaceutical compositions can be specially formulated for oral administration in solid or liquid form, for parenteral injection or for rectal administration.

The pharmaceutical compositions of this invention can be administered to humans and other mammals orally, rectally, parenterally, intracisternally, intravaginally, intraperitoneally, topically (as by powders, ointments or drops), buccally or as an oral or nasal spray. The term "parenterally," as used herein, refers to modes of administration

which include intravenous, intramuscular, intraperitoneal, intrasternal, subcutaneous and intraarticular injection and infusion.

Pharmaceutical compositions of this invention for parenteral injection comprise pharmaceutically acceptable sterile aqueous or nonaqueous solutions, dispersions, suspensions or emulsions as well as sterile powders for reconstitution into sterile injectable solutions or dispersions just prior to use. Examples of suitable aqueous and nonaqueous carriers, diluents, solvents or vehicles include water, ethanol, polyols (such as glycerol, propylene glycol, polyethylene glycol and the like), vegetable oils (such as olive oil), injectable organic esters (such as ethyl oleate) and suitable mixtures thereof. Proper fluidity can be maintained, for example, by the use of coating materials such as lecithin, by the maintenance of the required particle size in the case of dispersions and by the use of surfactants.

These compositions may also contain adjuvants such as preservatives, wetting agents, emulsifying agents and dispersing agents. Prevention of the action of microorganisms can be ensured by the inclusion of various antibacterial and antifungal agents, for example, paraben, chlorobutanol, phenol sorbic acid and the like. It may also be desirable to include isotonic agents such as sugars, sodium chloride and the like. Prolonged absorption of the injectable pharmaceutical form can be brought about by the inclusion of agents which delay absorption such as aluminum monostearate and gelatin.

In some cases, in order to prolong the effect of the drug, it is desirable to slow the absorption of the drug from subcutaneous or intramuscular injection. This can be accomplished by the use of a liquid suspension of crystalline or amorphous material with poor water solubility. The rate of absorption of the drug then depends upon its rate of dissolution which, in turn, may depend upon crystal size and crystalline form. Alternatively, delayed absorption of a parenterally administered drug form is accomplished by dissolving or suspending the drug in an oil vehicle.

Injectable depot forms are made by forming microencapsule matrices of the drug in biodegradable polymers such as polylactide-polyglycolide. Depending upon the ratio of drug to polymer and the nature of the particular polymer employed, the rate of drug release can be controlled. Examples of other biodegradable polymers include poly(orthoesters) and poly(anhydrides). Depot injectable formulations are also prepared

by entrapping the drug in liposomes or microemulsions which are compatible with body tissues.

The injectable formulations can be sterilized, for example, by filtration through a bacterial-retaining filter or by incorporating sterilizing agents in the form of sterile solid compositions which can be dissolved or dispersed in sterile water or other sterile injectable medium just prior to use.

Solid dosage forms for oral administration include capsules, tablets, pills, powders and granules. In such solid dosage forms, the active compound may be mixed with at least one inert, pharmaceutically acceptable excipient or carrier, such as sodium citrate or dicalcium phosphate and/or a) fillers or extenders such as starches, lactose, sucrose, glucose, mannitol and silicic acid; b) binders such as carboxymethylcellulose, alginates, gelatin, polyvinylpyrrolidone, sucrose and acacia; c) humectants such as glycerol; d) disintegrating agents such as agar-agar, calcium carbonate, potato or tapioca starch, alginic acid, certain silicates and sodium carbonate; e) solution retarding agents such as paraffin; f) absorption accelerators such as quaternary ammonium compounds; g) wetting agents such as cetyl alcohol and glycerol monostearate; h) absorbents such as kaolin and bentonite clay and i) lubricants such as talc, calcium stearate, magnesium stearate, solid polyethylene glycols, sodium lauryl sulfate and mixtures thereof. In the case of capsules, tablets and pills, the dosage form may also comprise buffering agents.

Solid compositions of a similar type may also be employed as fillers in soft and hard-filled gelatin capsules using such excipients as lactose or milk sugar as well as high molecular weight polyethylene glycols and the like.

The solid dosage forms of tablets, dragees, capsules, pills and granules can be prepared with coatings and shells such as enteric coatings and other coatings well-known in the pharmaceutical formulating art. They may optionally contain opacifying agents and may also be of a composition such that they release the active ingredient(s) only, or preferentially, in a certain part of the intestinal tract, optionally, in a delayed manner. Examples of embedding compositions which can be used include polymeric substances and waxes.

The active compounds can also be in micro-encapsulated form, if appropriate, with one or more of the above-mentioned excipients.

Liquid dosage forms for oral administration include pharmaceutically acceptable emulsions, solutions, suspensions, syrups and elixirs. In addition to the active compounds, the liquid dosage forms may contain inert diluents commonly used in the art such as, for example, water or other solvents, solubilizing agents and emulsifiers such as  
5 ethyl alcohol, isopropyl alcohol, ethyl carbonate, ethyl acetate, benzyl alcohol, benzyl benzoate, propylene glycol, 1,3-butylene glycol, dimethyl formamide, oils (in particular, cottonseed, groundnut, corn, germ, olive, castor and sesame oils), glycerol, tetrahydrofurfuryl alcohol, polyethylene glycols and fatty acid esters of sorbitan and mixtures thereof.

10 Besides inert diluents, the oral compositions may also include adjuvants such as wetting agents, emulsifying and suspending agents, sweetening, flavoring and perfuming agents.

Suspensions, in addition to the active compounds, may contain suspending agents as, for example, ethoxylated isostearyl alcohols, polyoxyethylene sorbitol and sorbitan  
15 esters, microcrystalline cellulose, aluminum metahydroxide, bentonite, agar-agar, tragacanth and mixtures thereof.

Compositions for rectal or vaginal administration are preferably suppositories which can be prepared by mixing the compounds of this invention with suitable non-irritating excipients or carriers such as cocoa butter, polyethylene glycol or a suppository  
20 wax which are solid at room temperature but liquid at body temperature and therefore melt in the rectum or vaginal cavity and release the active compound.

Compounds of the present invention can also be administered in the form of liposomes. As is known in the art, liposomes are generally derived from phospholipids or other lipid substances. Liposomes are formed by mono- or multi-lamellar hydrated  
25 liquid crystals which are dispersed in an aqueous medium. Any non-toxic, physiologically acceptable and metabolizable lipid capable of forming liposomes can be used. The present compositions in liposome form can contain, in addition to a compound of the present invention, stabilizers, preservatives, excipients and the like. The preferred lipids are natural and synthetic phospholipids and phosphatidyl cholines (lecithins) used  
30 separately or together.

Methods to form liposomes are known in the art. See, for example, Prescott, Ed.,

Methods in Cell Biology, Volume XIV, Academic Press, New York, N.Y. (1976), p. 33 et seq.

Compounds of the present invention that are formed by in vivo conversion of a different compound that was administered to a mammal are intended to be included within the scope of the present invention.

The compounds of the invention can exist in unsolvated as well as solvated forms, including hydrated forms, such as hemi-hydrates. In general, the solvated forms, with pharmaceutically acceptable solvents such as water and ethanol among others are equivalent to the unsolvated forms for the purposes of the invention.

The present compounds may have activity against disorders which are mediated through the central nervous system. The following references describe various disorders affected by nicotinic acetylcholine receptors: 1) Williams, M.; Arneric, S. P.: Beyond the Tobacco Debate: dissecting out the therapeutic potential of nicotine. Exp. Opin. Invest. Drugs (1996)5(8): 1035-1045; 2) Arneric, S. P.; Sullivan, J. P.; Williams, W.: Neuronal nicotinic acetylcholine receptors. Novel targets for central nervous system therapeutics. In: Psychopharmacology: The Fourth Generation of Progress. Bloom FE, Kupfer DJ (Eds.), Raven Press, New York (1995): 95-109; 3) Arneric, S. P.; Holladay, M. W.; Sullivan, J. P.: Cholinergic channel modulators as a novel therapeutic strategy for Alzheimer's disease. Exp. Opin. Invest. Drugs (1996) 5(1): 79-100; 4) Lindstrom, J.: Nicotinic Acetylcholine Receptors in Health and Disease. Molecular Neurobiology (1997) 15: 193-222; and 5) Lloyd, G K; Menzaghi, F; Bontempi B; Suto, C; Siegel, R; Akong, M; Stauderman, K; Velicelebi, G; Johnson, E; Harpold, M M; Rao, T S; Sacaan, A I; Chavez-Noriega, L E; Washburn, M S; Vernier, J M; Cosford, N D P; McDonald, L A: The potential of subtype-selective neuronal nicotinic acetylcholine receptor agonists as therapeutic agents. Life Sciences (1998)62(17/18): 1601-1606.

These disorders include, but are not limited to the following: pain (references 1 and 2), Alzheimer's disease (references 1-5), Parkinson's disease (references 1, 4 and 5), memory dysfunction, Tourette's syndrome (references 1, 2 and 4), sleep disorders (reference 1), attention deficit hyperactivity disorder (references 1 and 3), neurodegeneration, inflammation, neuroprotection (references 2 and 3), amyotrophic lateral sclerosis, anxiety (references 1, 2 and 3), depression (reference 2), mania,

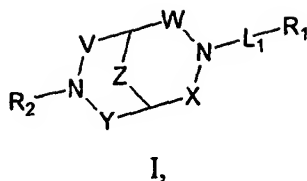
schizophrenia (references 1, 2 and 4), anorexia and other eating disorders, AIDS-induced dementia, epilepsy (references 1,2 and 4), urinary incontinence (reference 1), Crohn's disease, migraines, PMS, erectile dysfunction, substance abuse, smoking cessation (references 1 and 2) and inflammatory bowel syndrome (references 1 and 4) among  
5 others.

The present invention is illustrated by way of the foregoing description and examples. The foregoing description is intended as a non-limiting illustration, since many variations will become apparent to those skilled in the art in view thereof. It is intended that all such variations within the scope and spirit of the appended claims be  
10 embraced thereby.

Changes can be made in the composition, operation and arrangement of the method of the present invention described herein without departing from the concept and scope of the invention as defined in the following claims:

## WE CLAIM:

1. A compound of formula I



5 or a pharmaceutically acceptable salt thereof wherein:

V is selected from the group consisting of a covalent bond and CH<sub>2</sub>;

W is selected from the group consisting of a covalent bond, CH<sub>2</sub>, and CH<sub>2</sub>CH<sub>2</sub>;

X is selected from the group consisting of a covalent bond and CH<sub>2</sub>;

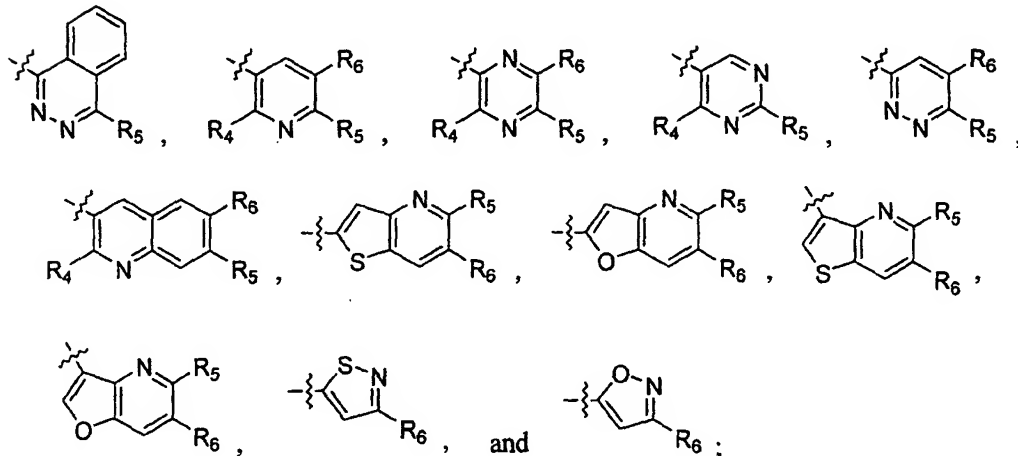
Y is selected from the group consisting of a covalent bond, CH<sub>2</sub>, and CH<sub>2</sub>CH<sub>2</sub>;

10 Z is selected from the group consisting of CH<sub>2</sub>, CH<sub>2</sub>CH<sub>2</sub>, and CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>;

L<sub>1</sub> is selected from the group consisting of a covalent bond and (CH<sub>2</sub>)<sub>n</sub>;

n is 1-5;

R<sub>1</sub> is selected from the group consisting of



15

R<sub>2</sub> is selected from the group consisting of hydrogen, alkoxycarbonyl, alkyl, aminoalkyl, aminocarbonylalkyl, benzyloxycarbonyl, cyanoalkyl, dihydro-3-pyridinylcarbonyl, hydroxy, hydroxyalkyl, phenoxycarbonyl, and -NH<sub>2</sub>;

R<sub>4</sub> is selected from the group consisting of hydrogen, alkyl, and halogen;

20 R<sub>5</sub> is selected from the group consisting of hydrogen, alkoxy, alkyl, halogen, nitro, and -NH<sub>2</sub>;



$R_6$  is selected from the group consisting of hydrogen, alkenyl, alkoxy, alkoxyalkoxy, alkoxyalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, alkyl, alkylcarbonyl, alkylcarbonyloxy, alkylthio, alkynyl, amino, aminoalkyl, aminocarbonyl, aminocarbonylalkyl, aminosulfonyl, carboxy, carboxyalkyl, cyano, cyanoalkyl, formyl, formylalkyl, haloalkoxy, haloalkyl, halogen, hydroxy, hydroxyalkyl, mercapto, mercaptoalkyl, nitro, 5-tetrazolyl,  $-NR_7SO_2R_8$ ,  $-C(NR_7)NR_7R_8$ ,  $-CH_2C(NR_7)NR_7R_8$ ,  $-C(NOR_7)R_8$ ,  $-C(NCN)R_7$ ,  $-C(NNR_7R_8)R_8$ ,  $-S(O)_2OR_7$ , and  $-S(O)_2R_7$ ; and

$R_7$  and  $R_8$  are independently selected from the group consisting of hydrogen and alkyl;

with the proviso that the following compounds are excluded,

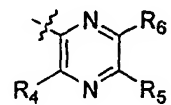
3-(6-chloro-3-pyridazinyl)-3,8-diazabicyclo[3.2.1]octane;

3-(6-chloro-2-pyrazinyl)-3,8-diazabicyclo[3.2.1]octane;

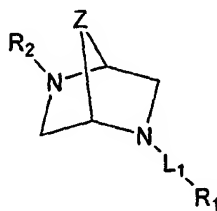
8-(6-chloro-3-pyridazinyl)-3,8-diazabicyclo[3.2.1]octane; and

8-(6-chloro-2-pyrazinyl)-3,8-diazabicyclo[3.2.1]octane; and

with the further proviso that when V and X are each a covalent bond; W, Y, and Z are each  $CH_2$ ; and  $L_1$  is a covalent bond; then  $R_1$  is other than



2. A compound according to claim 1 of formula II



II,

or a pharmaceutically acceptable salt thereof wherein:

Z is selected from the group consisting of  $CH_2$  and  $CH_2CH_2$ .

25

3. A compound according to claim 2 selected from the group consisting of:

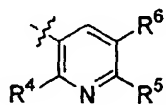
- (1S,4S)-2-(6-chloro-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1S,4S)-2-(6-chloro-5-methyl-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1S,4S)-2-(6-chloro-3-pyridazinyl)-5-methyl-2,5-diazabicyclo[2.2.1]heptane;  
 (1S,4S)-2-(6-chloro-5-methyl-3-pyridazinyl)-5-methyl-2,5-  
 5 diazabicyclo[2.2.1]heptane;  
 (1S,4S)-2-(4-chloro-1-phthalazinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1S,4S)-2-(4-chloro-1-phthalazinyl)-5-methyl-2,5-diazabicyclo[2.2.1]heptane;  
 (1S,4S)-2-(6-chloro-5-methoxycarbonyl-3-pyridazinyl)-2,5-  
 diazabicyclo[2.2.1]heptane;  
 10 (1S,4S)-2-(3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1S,4S)-2-(5-pyrimidinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1S,4S)-2-(3-quinolinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1S,4S)-2-(3-methyl-5-isothiazolyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1S,4S)-2-(thieno[3,2-b]pyridin-2-yl)-2,5-diazabicyclo[2.2.1]heptane; and  
 15 (1S,4S)-2-(furo[3,2-b]pyridin-2-yl)-2,5-diazabicyclo[2.2.1]heptane.

4. A compound according to claim 2 wherein:

Z is CH<sub>2</sub>;

L<sub>1</sub> is a covalent bond; and

20 R<sub>1</sub> is



5. A compound according to claim 4 selected from the group consisting of:

- (1S,4S)-2-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 25 (1S,4S)-2-(6-amino-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1S,4S)-2-(3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1S,4S)-2-[5-(benzyloxy)-3-pyridinyl]-2,5-diazabicyclo[2.2.1]heptane;  
 (1S,4S)-2-[5-hydroxy-3-pyridinyl]-2,5-diazabicyclo[2.2.1]heptane;  
 (1S,4S)-2-(6-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

- (1S,4S)-2-(6-nitro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-bromo-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
5 (1S,4S)-2-(5-aminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-aminocarbonyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-chloro-5-hydroxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-chloro-3-pyridinyl)-5-cyanomethyl-2,5-diazabicyclo[2.2.1]heptane;  
10 (1S,4S)-2-(6-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-chloro-5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-chloro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5,6-dichloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-chloro-5-ethynyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
15 (1S,4S)-2-(6-chloro-5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(6-fluoro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-ethynyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-cyano-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
20 (1S,4S)-2-(5-bromo-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-cyano-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-hydroxymethyl-6-chloro-3-pyridinyl)-2,5-  
diazabicyclo[2.2.1]heptane; (1S,4S)-2-(5-hydroxymethyl-6-fluoro-3-pyridinyl)-2,5-  
diazabicyclo[2.2.1]heptane;  
25 (1S,4S)-2-(5-hydroxymethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-aminomethyl-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-aminomethyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-aminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-carboxy-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
30 (1S,4S)-2-(5-carboxy-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1S,4S)-2-(5-carboxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

(1S,4S)-2-(5-aminocarbonyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

(1S,4S)-2-(5-aminocarbonyl-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

5 (1S,4S)-2-(6-chloro-5-hydroxyiminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

(1S,4S)-2-(6-fluoro-5-hydroxyiminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

(1S,4S)-2-(5-hydroxyiminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

10 (1S,4S)-2-(2-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

(1S,4S)-2-(5-methyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

(1S,4S)-2-(5-aminosulfonyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;

15 (1S,4S)-2-(5-aminosulfonyl-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane; and

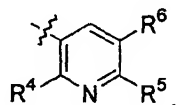
(1S,4S)-2-(5-aminosulfonyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane.

6. A compound according to claim 2 wherein:

Z is  $\text{CH}_2\text{CH}_2$ ;

20  $\text{L}_1$  is a covalent bond; and

$\text{R}_1$  is



7. A compound according to claim 6 selected from the group consisting of:

25 (1S,4S)-2-(6-chloro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;

(1S,4S)-2-(5,6-dichloro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;

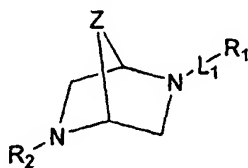
(1S,4S)-2-(6-chloro-5-ethynyl-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;

(1S,4S)-2-(6-chloro-5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;

(1S,4S)-2-(5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;

- (1S,4S)-2-(6-fluoro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1S,4S)-2-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1S,4S)-2-(5-ethynyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1S,4S)-2-(5-cyano-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 5 (1S,4S)-2-(5-bromo-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;  
 (1S,4S)-2-(3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane; and  
 (1S,4S)-2-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane.

8. A compound according to claim 1 of formula III



10

III,

or a pharmaceutically acceptable salt wherein:

Z is selected from the group consisting of  $\text{CH}_2$  and  $\text{CH}_2\text{CH}_2$ .

- 15 9. A compound according to claim 8 selected from the group consisting of:  
 (1R,4R)-2-(6-chloro-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(thieno[3,2-b]pyridin-2-yl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(furo[3,2-b]pyridin-2-yl)-2,5-diazabicyclo[2.2.1]heptane;  
 20 (1R,4R)-2-(6-chloro-5-methyl-3-pyridazinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(6-chloro-3-pyridazinyl)-5-methyl-2,5-diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(6-chloro-5-methyl-3-pyridazinyl)-5-methyl-2,5-  
 diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(4-chloro-1-phthalazinyl)-2,5-diazabicyclo[2.2.1]heptane;  
 25 (1R,4R)-2-(4-chloro-1-phthalazinyl)-5-methyl-2,5-diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(6-chloro-5-methoxycarbonyl-3-pyridazinyl)-2,5-  
 diazabicyclo[2.2.1]heptane;  
 (1R,4R)-2-(5-pyrimidinyl)-2,5-diazabicyclo[2.2.1]heptane;

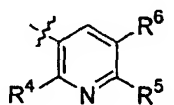
(1R,4R)-2-(3-quinoliny)-2,5-diazabicyclo[2.2.1]heptane; and  
 (1R,4R)-2-(3-methyl-5-isothiazolyl)-2,5-diazabicyclo[2.2.1]heptane.

10. A compound according to claim 8 wherein:

5 Z is CH<sub>2</sub>;

L<sub>1</sub> is a covalent bond; and

R<sub>1</sub> is



10 11. A compound according to claim 10 selected from the group consisting of:

- (1R,4R)-2-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-(3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-(6-chloro-3-pyridinyl)-5-cyanomethyl-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- 15 (1R,4R)-2-(5-hydroxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-(6-chloro-5-hydroxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-(5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-(6-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-(6-chloro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- 20 (1R,4R)-2-(5,6-dichloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-(5-aminocarbonyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-(6-chloro-5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-(5-bromo-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-(6-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- 25 (1R,4R)-2-(6-nitro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-(5-bromo-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-(6-amino-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;
- (1R,4R)-2-[5-(benzyloxy)-3-pyridinyl]-2,5-diazabicyclo[2.2.1]heptane;

- (1R,4R)-2-(6-chloro-5-ethynyl-3-pyridinyl)-2,5diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(6-chloro-5-cyano-3-pyridinyl)-2,5diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-ethynyl-6-fluoro-3-pyridinyl)-2,5diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-cyano-6-fluoro-3-pyridinyl)-2,5diazabicyclo[2.2.1]heptane;  
5 (1R,4R)-2-(5-bromo-6-chloro-3-pyridinyl)-2,5diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-cyano-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-hydroxymethyl-6-chloro-3-pyridinyl)-2,5-  
diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-hydroxymethyl-6-fluoro-3-pyridinyl)-2,5-  
10 diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-hydroxymethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-aminomethyl-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-aminomethyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-aminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
15 (1R,4R)-2-(5-carboxy-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-carboxy-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-carboxy-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-aminocarbonyl-6-fluoro-3-pyridinyl)-2,5-  
diazabicyclo[2.2.1]heptane;  
20 (1R,4R)-2-(5-aminocarbonyl-6-chloro-3-pyridinyl)-2,5-  
diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(6-chloro-5-hydroxyiminomethyl-3-pyridinyl)-2,5-  
diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(6-fluoro-5-hydroxyiminomethyl-3-pyridinyl)-2,5-  
25 diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-hydroxyiminomethyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(2-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-methyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-aminosulfonyl-6-fluoro-3-pyridinyl)-2,5-  
30 diazabicyclo[2.2.1]heptane;  
(1R,4R)-2-(5-aminosulfonyl-6-chloro-3-pyridinyl)-2,5-

diazabicyclo[2.2.1]heptane; and

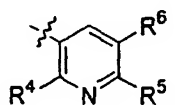
(1R,4R)-2-(5-aminosulfonyl-3-pyridinyl)-2,5-diazabicyclo[2.2.1]heptane.

12. A compound according to claim 8 wherein:

5 Z is  $\text{CH}_2\text{CH}_2$ ;

$\text{L}_1$  is a covalent bond; and

$\text{R}_1$  is



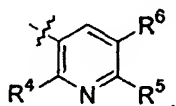
- 10 13. A compound according to claim 12 selected from the group consisting of:
- (1R,4R)-2-(6-chloro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;
- (1R,4R)-2-(5,6-dichloro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;
- (1R,4R)-2-(6-chloro-5-ethynyl-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;
- (1R,4R)-2-(6-chloro-5-cyano-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;
- 15 (1R,4R)-2-(5-methoxy-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;
- (1R,4R)-2-(6-fluoro-5-methyl-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;
- (1R,4R)-2-(6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;
- (1R,4R)-2-(5-ethynyl-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;
- (1R,4R)-2-(5-cyano-6-fluoro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;
- 20 (1R,4R)-2-(5-bromo-6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane;
- (1R,4R)-2-(3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane; and
- (1R,4R)-2-(6-chloro-3-pyridinyl)-2,5-diazabicyclo[2.2.2]octane.

14. A compound according to claim 8 wherein:

25 Z is  $\text{CH}_2$ ;

$\text{L}_1$  is  $(\text{CH}_2)_q$ ; and

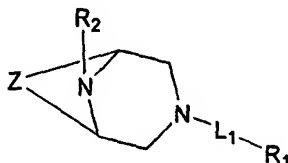
$\text{R}_1$  is





15. A compound according to claim 14 that is (1R,4R)-2-(3-pyridinylmethyl)-2,5-diazabicyclo[2.2.1]heptane.

5 16. A compound according to claim 1 of formula IV



IV,

or a pharmaceutically acceptable salt thereof wherein:

Z is selected from the group consisting of  $\text{CH}_2\text{CH}_2$  and  $\text{CH}_2\text{CH}_2\text{CH}_2$ .

10

17. A compound according to claim 16 wherein Z is  $\text{CH}_2\text{CH}_2$ .

18. A compound according to claim 17 that is 3-(3-pyridazinyl)-3,8-diazabicyclo[3.2.1]octane.

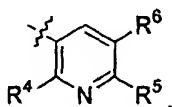
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19. A compound according to claim 16 wherein:

Z is  $\text{CH}_2\text{CH}_2$ ;

$\text{L}_1$  is a covalent bond; and

$\text{R}_1$  is



20

20. A compound according to claim 19 selected from the group consisting of:

3-(6-nitro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;

3-(6-amino-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;

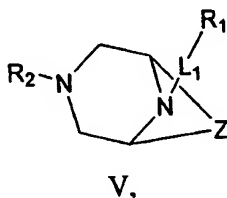
25 3-(6-chloro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;

3-(3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;

3-(6-chloro-5-methyl-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;

- 3-(5,6-dichloro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(6-chloro-5-ethynyl-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(6-chloro-5-cyano-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(5-methoxy-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 5 3-(6-fluoro-5-methyl-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(6-fluoro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(5-ethynyl-6-fluoro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(5-cyano-6-fluoro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(5-bromo-6-chloro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 10 3-(5-aminomethyl-6-chloro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane;  
 3-(5-aminomethyl-6-fluoro-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane; and  
 3-(5-aminomethyl-3-pyridinyl)-3,8-diazabicyclo[3.2.1]octane.

21. A compound according to claim 1 of formula V



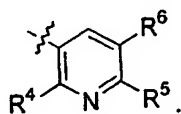
or a pharmaceutically acceptable salt wherein:

Z is selected from the group consisting of  $\text{CH}_2\text{CH}_2$  and  $\text{CH}_2\text{CH}_2\text{CH}_2$ .

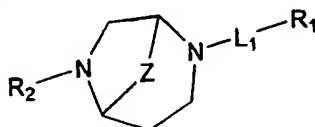
- 20 22. A compound according to claim 21 wherein:

$L_1$  is a covalent bond; and

$R_1$  is



- 25 23. A compound according to claim 1 of formula VI



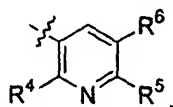
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VI,

or a pharmaceutically acceptable salt wherein:

Z is selected from the group consisting of  $\text{CH}_2$  and  $\text{CH}_2\text{CH}_2$ .

- 5     24. A compound according to claim 23 wherein:

Z is  $\text{CH}_2$ ; $\text{L}_1$  is a covalent bond; and $\text{R}_1$  is

10

25. A compound according to claim 24 selected from the group consisting of:

2-(6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

2-(3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(6-chloro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

15     (1S,5R)-2-(5,6-dichloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(6-chloro-5-ethynyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(6-chloro-5-cyano-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(5-methoxy-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(6-fluoro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

20     (1S,5R)-2-(6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(5-ethynyl-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(5-cyano-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-2-(5-bromo-6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1R,5S)-2-(6-chloro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

25     (1R,5S)-2-(5,6-dichloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1R,5S)-2-(6-chloro-5-ethynyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1R,5S)-2-(6-chloro-5-cyano-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

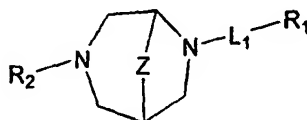
(1R,5S)-2-(5-methoxy-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1R,5S)-2-(6-fluoro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1R,5S)-2-(6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-2-(5-ethynyl-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-2-(5-cyano-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane; and  
 (1R,5S)-2-(5-bromo-6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane.

5

26. A compound according to claim 1 of formula VII



VII,

or a pharmaceutically acceptable salt wherein:

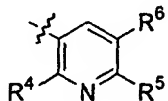
10

Z is selected from the group consisting of  $\text{CH}_2$  and  $\text{CH}_2\text{CH}_2$ .

27. A compound according to claim 26 wherein

$\text{L}_1$  is a covalent bond and

$\text{R}_1$  is



15

28. A compound according to claim 27 selected from the group consisting of:

(1R,5R)-6-(6-chloro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;

(1R,5R)-6-(5,6-dichloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;

20

(1R,5R)-6-(6-chloro-5-ethynyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;

(1R,5R)-6-(6-chloro-5-cyano-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;

(1R,5R)-6-(5-methoxy-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;

(1R,5R)-6-(6-fluoro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;

(1R,5R)-6-(6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;

25

(1R,5R)-6-(5-ethynyl-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;

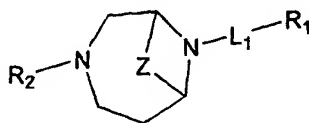
(1R,5R)-6-(5-cyano-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;

(1R,5R)-6-(5-bromo-6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;

(1R,5R)-6-(3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;

- (1R,5R)-6-(6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(6-chloro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(5,6-dichloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(6-chloro-5-ethynyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 5 (1S,5S)-6-(6-chloro-5-cyano-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(5-methoxy-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(6-fluoro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(5-ethynyl-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 10 (1S,5S)-6-(5-cyano-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(5-bromo-6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-6-(3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane; and  
 (1S,5S)-6-(6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane.

- 15 29. A compound according to claim 1 of formula VIII



VIII,

or a pharmaceutically acceptable salt wherein:

Z is selected from the group consisting of  $\text{CH}_2\text{CH}_2$  and  $\text{CH}_2\text{CH}_2\text{CH}_2$ .

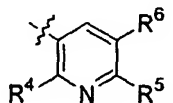
20

30. A compound according to claim 29 wherein

Z is  $\text{CH}_2\text{CH}_2$ ;

$\text{L}_1$  is a covalent bond; and

$\text{R}_1$  is



25

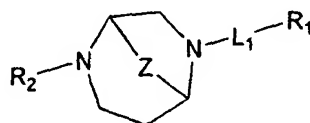
31. A compound according to claim 30 selected from the group consisting of:

9-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;

- (1R,6S)-9-(6-chloro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(5,6-dichloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(6-chloro-5-ethynyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(6-chloro-5-cyano-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 5 (1R,6S)-9-(5-methoxy-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(6-fluoro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(5-ethynyl-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(5-cyano-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 10 (1R,6S)-9-(5-bromo-6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1R,6S)-9-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(6-chloro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(5,6-dichloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 15 (1S,6R)-9-(6-chloro-5-ethynyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(6-chloro-5-cyano-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(5-methoxy-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(6-fluoro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 20 (1S,6R)-9-(5-ethynyl-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(5-cyano-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(5-bromo-6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
 (1S,6R)-9-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane; and  
 (1S,6R)-9-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane.

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32. A compound according to claim 1 of formula IX



IX,

or a pharmaceutically acceptable salt wherein:

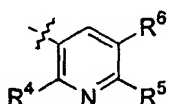
Z is selected from the group consisting of CH<sub>2</sub> and CH<sub>2</sub>CH<sub>2</sub>.

33. A compound according to claim 32 wherein:

Z is CH<sub>2</sub>;

5 L<sub>1</sub> is a covalent bond; and

R<sub>1</sub> is

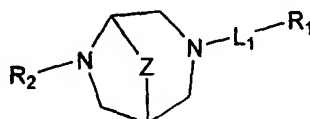


34. A compound according to claim 33 selected from the group consisting of:

- 10 6-(6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(6-chloro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(5,6-dichloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(6-chloro-5-ethynyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(6-chloro-5-cyano-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 15 (1R,5S)-6-(5-methoxy-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(6-fluoro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(5-ethynyl-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(5-cyano-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 20 (1R,5S)-6-(5-bromo-6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1R,5S)-6-(3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(6-chloro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(5,6-dichloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 25 (1S,5R)-6-(6-chloro-5-ethynyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(6-chloro-5-cyano-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(5-methoxy-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(6-fluoro-5-methyl-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;

(1S,5R)-6-(5-ethynyl-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(5-cyano-6-fluoro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(5-bromo-6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane;  
 (1S,5R)-6-(6-chloro-3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane; and  
 5 (1S,5R)-6-(3-pyridinyl)-2,6-diazabicyclo[3.2.1]octane.

35. A compound according to claim 1 of formula X



X,

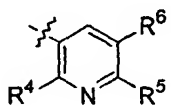
10 or a pharmaceutically acceptable salt wherein:

Z is selected from the group consisting of CH<sub>2</sub> and CH<sub>2</sub>CH<sub>2</sub>.

36. A compound according to claim 35 wherein

L<sub>1</sub> is a covalent bond and

15 R<sub>1</sub> is



37. A compound according to claim 36 selected from the group consisting of:

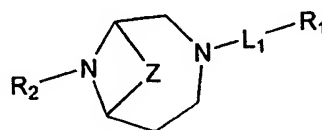
(1R,5R)-3-(6-chloro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 20 (1R,5R)-3-(5,6-dichloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-3-(6-chloro-5-ethynyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-3-(6-chloro-5-cyano-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-3-(5-methoxy-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-3-(6-fluoro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 25 (1R,5R)-3-(6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-3-(5-ethynyl-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-3-(5-cyano-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-3-(5-bromo-6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;



- (1R,5R)-3-(6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1R,5R)-3-(3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-3-(6-chloro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-3-(5,6-dichloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 5 (1S,5S)-3-(6-chloro-5-ethynyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-3-(6-chloro-5-cyano-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-3-(5-methoxy-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-3-(6-fluoro-5-methyl-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-3-(6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 10 (1S,5S)-3-(5-ethynyl-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-3-(5-cyano-6-fluoro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-3-(5-bromo-6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane;  
 (1S,5S)-3-(6-chloro-3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane; and  
 (1S,5S)-3-(3-pyridinyl)-3,6-diazabicyclo[3.2.1]octane.

15

38. A compound according to claim 1 of formula XI



XI,

or a pharmaceutically acceptable salt wherein:

20

Z is selected from the group consisting of  $\text{CH}_2\text{CH}_2$  and  $\text{CH}_2\text{CH}_2\text{CH}_2$ .

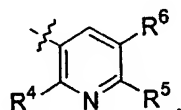
39. A compound according to claim 38 wherein

Z is  $\text{CH}_2\text{CH}_2$ ;

$\text{L}_1$  is a covalent bond; and

25

$\text{R}_1$  is

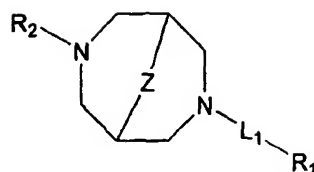


40. A compound according to claim 39 selected from the group consisting of:

- 3-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
9-methyl-3-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
3-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1R,6S)-3-(6-chloro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
5 (1R,6S)-3-(5,6-dichloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1R,6S)-3-(6-chloro-5-ethynyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1R,6S)-3-(6-chloro-5-cyano-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1R,6S)-3-(5-methoxy-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1R,6S)-3-(6-fluoro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
10 (1R,6S)-3-(6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1R,6S)-3-(5-ethynyl-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1R,6S)-3-(5-cyano-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1R,6S)-3-(5-bromo-6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1R,6S)-3-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
15 (1R,6S)-3-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1S,6R)-3-(6-chloro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1S,6R)-3-(5,6-dichloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1S,6R)-3-(6-chloro-5-ethynyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1S,6R)-3-(6-chloro-5-cyano-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
20 (1S,6R)-3-(5-methoxy-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1S,6R)-3-(6-fluoro-5-methyl-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1S,6R)-3-(6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1S,6R)-3-(5-ethynyl-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1S,6R)-3-(5-cyano-6-fluoro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
25 (1S,6R)-3-(5-bromo-6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane;  
(1S,6R)-3-(6-chloro-3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane; and  
(1S,6R)-3-(3-pyridinyl)-3,9-diazabicyclo[4.2.1]nonane.

41. A compound according to claim 1 of formula XII

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XII,

or a pharmaceutically acceptable salt wherein:

Z is selected from the group consisting of  $\text{CH}_2$  and  $\text{CH}_2\text{CH}_2$ .

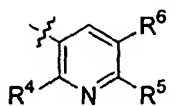
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42. A compound according to claim 41 wherein:

Z is  $\text{CH}_2$ ;

$\text{L}_1$  is a covalent bond; and

$\text{R}_1$  is



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43. A compound according to claim 42 selected from the group consisting of:

3-(3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;

3-(6-chloro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;

15 3-(6-chloro-5-methyl-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;

3-(5,6-dichloro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;

3-(6-chloro-5-ethynyl-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;

3-(6-chloro-5-cyano-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;

3-(5-methoxy-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;

20 3-(6-fluoro-5-methyl-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;

3-(6-fluoro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;

3-(5-ethynyl-6-fluoro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane;

3-(5-cyano-6-fluoro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane; and

3-(5-bromo-6-chloro-3-pyridinyl)-3,7-diazabicyclo[3.3.1]nonane.

25

44. A pharmaceutical composition comprising a therapeutically effective amount of a compound of formula I in combination with a pharmaceutically acceptable carrier.

45. A method for selectively controlling neurotransmitter release in a mammal comprising administering to a mammal in need of such treatment a therapeutically effective amount of a compound of formula I.

5

46. A method of treating a disorder in a host mammal in need of such treatment comprising administering a therapeutically effective amount of a compound of formula I.

10 47. The method of claim 46 wherein the disorder is selected from the group consisting of Alzheimer's disease, Parkinson's disease, memory dysfunction, Tourette's syndrome, sleep disorders, attention deficit hyperactivity disorder, neurodegeneration, inflammation, neuroprotection, amyotrophic atal sclerosis, anxiety, depression, mania, schizophrenia, anorexia and other eating disorders, AIDS-induced dementia, epilepsy,  
15 urinary incontinence, Crohn's disease, migraines, premenstrual syndrome, erectile dysfunction, substance abuse, smoking cessation, and inflammatory bowel syndrome.

48. The method of claim 46 wherein the disorder is pain.

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 00/01620

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C07D487/08 A61K31/395 A61P25/00 C07D471/08 C07D519/00  
 //(C07D487/08,209:00,209:00),(C07D487/08,241:00,209:00),  
 (C07D471/08,221:00,209:00),(C07D487/08,243:00,209:00),

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C07D A61K A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

CHEM ABS Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 98 54181 A (NEUROSEARCH A/S) 3 December 1998 (1998-12-03) claims 1,6 ---	1,44
A	WO 98 54182 A (NEUROSEARCH A/S) 3 December 1998 (1998-12-03) claims 1,6 ---	1,44
A	US 5 478 939 A (EUGENE TRYBULSKI ET AL.) 26 December 1995 (1995-12-26) cited in the application * complete document * --- -/--	1

☒ Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search

14 June 2000

Date of mailing of the international search report

06/07/2000

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Authorized officer

Van Bijlen, H

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 00/01620

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 (C07D471/08, 221:00, 221:00)

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DANIELA BARLOCCO ET AL.: "Mono- and disubstituted-3,8-diazabicyclo(3.2.1)octane derivatives as analgesics structurally related to epibatidine: synthesis, activity, and modeling" JOURNAL OF MEDICINAL CHEMISTRY., vol. 41, no. 5, - 1998 pages 674-681, XP002140147 AMERICAN CHEMICAL SOCIETY. WASHINGTON., US ISSN: 0022-2623 cited in the application page 674 -----	1

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Date of the actual completion of the international search

14 June 2000

Date of mailing of the international search report

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Van Bijlen, H

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/01620

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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WO 9854182 A	03-12-1998	AU 7426098 A EP 0984966 A ZA 9804640 A	30-12-1998 15-03-2000 11-12-1998
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